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DESTROYER ENGINEERED OPERATING CYCLE (DDEOC)

LEVEL II

System Maintenance Analysis
CG-16 and CG-26 CLASS
1200 PSI PROPULSION PLANT
SWAB GROUP 200
SMA 1626-200
REVIEW OF EXPERIENCE

November 1979

Prepared for
Director, Escort and Cruiser
Ship Logistic Division
Naval Sea Systems Command
Washington, D.C.
under Contract N00024-80-C-4026

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This report, the review of experience, documents the historical maintenance experience for both CG-16 and CG-26 Class 1200 psi propulsion plants, SWAB group 200. It presents an anlysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-80-C-4026.

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DESTROYER ENGINEERED OPERATING CYCLE
(DDEOC)

SYSTEM MAINTENANCE ANALYSIS
CG-16 AND CG-26 CLASS
1200 PSI PROPULSION PLANT
SWAB GROUP 200
SMA 1626-200

REVIEW OF EXPERIENCE

11
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15
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FOREWORD

This report, the review of experience, documents the historical maintenance experience for both CG-16 and CG-26 Class 1200 psi propulsion plants, SWAB group 200. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-80-C-4026.

SUMMARY

The goal of the Destroyer Engineered Operating Cycle (DDEOC) Program is to effect an early improvement in the material condition of ships at an acceptable cost, while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, system maintenance analyses (SMAs) are being conducted for selected systems and subsystems of designated surface combatants. The principal element of an SMA is the review of experience (ROE). This report documents the ROE for the CG-16 and CG-26 Class 1200 psi propulsion plants, SWAB group 200.

The ROE is an analysis of the impact of the historical maintenance requirements on the operational performance and maintenance program of a ship system and the significance of these requirements to the DDEOC Program. The report documents a recommended system maintenance policy and specific maintenance actions best suited to meeting DDEOC goals.

The ROE for the 1200 psi propulsion plant included an analysis of all available maintenance data sources. The documented maintenance experience of the system was reviewed through analysis of data from the maintenance data system (MDS), casualty reports (CASREPs), and system overhaul records. Initial findings from these sources were correlated with planned maintenance system (PMS) requirements, the alterations program, and system technical manuals. Selected ships were surveyed and discussions were held with appropriate technical groups to validate identified maintenance requirements, to identify undocumented maintenance requirements, and to determine the status of current and planned actions affecting the 1200 psi propulsion plants. All findings were evaluated and appropriate conclusions were developed.

A recommended system maintenance policy was defined on the basis of these conclusions; recommendations were then made to implement the policy by periodically accomplishing specific types of corrective maintenance actions. These actions were documented for inclusion as tasks in the CG-16 and CG-26 Class maintenance plans. Also included, as appropriate, were recommendations for improving system preventive maintenance; integrated logistics support; reliability, maintainability, and availability; and depot- and IMA-level capabilities. Implementing these combined recommendations will minimize the adverse impact of corrective maintenance requirements on the extended operating cycle.

The major findings and conclusions of this ROE for the CG-16 and CG-26 Class 1200 psi propulsion plants are summarized as follows:

- The maintenance histories of CG-16 and CG-26 Class 1200 psi propulsion plant equipments were similar to those of identical or functionally similar equipments installed in DDG-37 and FF-1052 Class ships.
- The following equipments will require class B overhaul during baseline overhaul: fuel oil burners, soot blower heads, the entire ACC/FWC/MFPC system, three of six main feed pumps and turbines, the Worthington and Terry main feed pump turbine steam admission valves and servomotors, two of four fuel oil service pumps, the fuel pressure regulating valves, the lube oil purifiers, and the standby lube oil pump turbines. All the other equipment analyzed in this report should be repaired as shown to be necessary by POT&I and each ship's CSMP.
- Scheduled restorative maintenance will be required during the operating cycle on the following equipments: boiler skirt casings, ACC/FWC/MFPC, forced draft blowers, and the forced draft blower turbine exhaust and relief valves.
- Major improvements are required to boilers and the main lube oil system to ensure reliable operation and improved performance during the operating cycle. Most of these improvements exist in the form of shipalts; however, some improvements must be explicitly defined and authorized. NAVSEA will require the support of the TYCOMs and NAVSEC to define and implement these improvements.
- A series of changes, deletions, and additions to PMS will improve the routine preventive maintenance of propulsion plant equipments during the operating cycle. These modifications will be required for the following equipments: safety valves and soot blowers, forced draft blower turbine exhaust and relief valves, main feed pump turbine steam admission valve, auxiliary circulating pump, lube oil purifiers, and standby lube oil pump turbines.
- Extensive improvements to the integrated logistics support (ILS) of the following systems will be required to effectively implement the recommended maintenance policies for propulsion plant equipments: boilers, ACC/FWC/MFPC, combustion air, feed and condensate, circulating and cooling, fuel oil service, and main lube oil. Improvements to the ILS include POT&I revisions; development and implementation of a management system to assist readiness support groups (RSGs) and similar IMA coordination centers in coordinating their work, quality assurance, contracts, and specification writing; changes to the engineering operational sequencing system (EOSS); deletion of routine overhaul of propulsion plant equipments from the DDEOC repair requirements for BOH; and issuance of 1200 psi improvement program advisories for specific equipments.
- This analysis has, as in the FF-1052 and DDG-37 analyses, determined that IMA capabilities to calibrate and repair ACC/FWC/MFPC systems are inadequate and should be improved.

Reliable operation of the 1200 psi propulsion plants can be expected throughout an extended operating cycle if the recommendations contained in this study are implemented and existing PMS maintenance requirements are adhered to.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

System maintenance analyses (SMAs) are being conducted as part of the Destroyer Engineered Operating Cycle (DDEOC) Program, managed by NAVSEA 931X. The principal element of an SMA is the review of experience (ROE) of selected systems and subsystems of program-designated surface combatants. This report documents the ROE for the CG-16 and CG-26 Class 1200 psi propulsion plants, SWAB group 200, which was selected for analysis because equipments of this system have been major contributors to the CG-16 and CG-26 Class maintenance burden.

1.2 PURPOSE AND SCOPE

The ROE is an analysis of the impact of the historical maintenance requirements on a ship system's operational performance and maintenance program. It serves as a vehicle for documenting the significance of historical maintenance requirements to the DDEOC Program.

The objective of the ROE is to define and document a maintenance program for CG-16 and CG-26 Class ships that will prevent or reduce the need for unscheduled maintenance while improving material condition and maintaining or increasing ship availability throughout an extended ship operating cycle. The maintenance program defined and documented in an ROE for a selected equipment will be the basis for maintenance tasks to be developed for inclusion in the class maintenance plan (CMP).

The analysis documented in this report is specifically applicable to the 1200 psi propulsion plant, SWAB group 200, of the CG-16 and CG-26 Class ships. This analysis utilized all available documented data sources from which system maintenance experience could be identified and studied. These included maintenance data system (MDS) data, casualty reports (CASREPs), Board of Inspection and Survey (INSURV) reports, departure reports, ship's alteration and repair packages (SARPs), planned maintenance system (PMS) requirements data, system alteration documentation, and system technical manuals. Sources of undocumented data used in this analysis included discussions with ship's force and cognizant Navy technical personnel.

1.3 REPORT FORMAT

The remaining chapters of this report describe the analysis approach (Chapter Two), briefly present the significant system maintenance experience and discuss essential maintenance requirements (Chapter Three), and summarize the conclusions and recommendations derived from the analysis (Chapter Four). Specific analyses, evaluations, and data compilations that support the findings of this effort are included, as necessary, in appendixes.

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach followed in performing the ROE for equipments and subsystems in the 1200 psi propulsion plants, SWAB group 200. These systems were identified for analysis in the DDEOC Selected Items for Analysis List, CG-16 and CG-26 Classes, ARINC Research Publication 1653-06-TR-1875. Primary data sources were identified in section 1.2. The data were used to identify, define, and analyze maintenance requirements that have significantly affected the system's operational availability and material condition. A recommended maintenance strategy and implementation procedures were formulated on the basis of analysis results. The major steps of the analysis were as follows:

- Relevant documented and undocumented historical maintenance data were compiled for the selected equipments or subsystems.

- These data were analyzed to identify and define recurring maintenance requirements that have a significant impact on the operational availability and material condition of these equipments or subsystems.

- The results of ROE analyses were compared with results of previously completed analyses of identical or functionally similar equipment or subsystems (on other classes of ships) to determine if previously identified maintenance strategies and implementation recommendations apply to CG-16 and CG-26 Class ships.

- If previously developed maintenance strategies and recommendations were determined to be applicable to similar equipment or subsystems of the CG-16 and CG-26 Class ships, they were identified and documented in this report. CMP tasks previously developed were modified to reflect their applicability to these two ship classes.

- Where previously developed maintenance strategies and implementation recommendations were not applicable to CG-16 and CG-26 Class ships, a detailed maintenance analysis was conducted to develop the maintenance strategy to be recommended and the steps to be employed in implementing that strategy.

2.2 DATA COMPILATION

The analysis began with the compilation of comprehensive data on the maintenance history of the system. The data file assembled consisted of four key elements: an MDS data bank, a CASREP narrative summary, a system overhaul experience summary, and a system shipalt summary. A library of appropriate technical manuals, bulletins, and related documents was also assembled. The MDS data bank was compiled by examining all MDS data reported for the CG-16 and CG-26 Classes from 1 January 1970 through 31 December 1977. In the case of the CG-16 Class, MDS data reported between 1 January 1970 and completion of modernization were not considered. Thus the data bank for ships of this class includes only the MDS reported maintenance actions occurring between the end of modernization and 31 December 1977. CASREP information was obtained by reviewing CASREPs against the various 1200 psi propulsion plants' equipments during the data period 1 January 1972 through 31 August 1978. Overhaul information was obtained from authorized SARPs and departure reports for ships of both classes.

2.3 MAINTENANCE DATA ANALYSIS

Recurring maintenance requirements affecting the availability and material condition of subsystems or equipments were identified by screening data obtained from the above-described sources, as well as from ship surveys, discussions with Navy technical personnel, and NAVSEA special interest programs.

MDS data provided the initial and primary source of information screened. The resulting data base includes all part and labor records, as well as narrative material, describing maintenance actions reported against system components. The purpose of the screening process was to identify the maintenance actions that had been reported against the 1200 psi propulsion plants' equipments.

Preliminary analysis of each of the equipments was directed toward determining the historical maintenance profile in terms of reported manhours per equipment operating year, types of maintenance actions commonly recurring, type and number of repair parts used, CASREP frequency, and past ROH experience. The historical maintenance profile was then compared with similar information developed for identical or functionally similar subsystems or equipments previously subjected to detailed analysis during the performance of ROEs for FF-1052 and DDG-37 Class ships. Further analysis was not conducted where the results of this comparison showed that the maintenance profile for the CG-16 or CG-26 Class equipment was essentially the same as that of an identical or functionally similar subsystem or equipment previously analyzed on another ship class. Instead, the maintenance strategy and implementation recommendations developed for the same or similar equipment on a previously analyzed ship class were identified as being applicable to the CG-16 or CG-26 Class ships, as documented in this report.

Where the results of the historical maintenance profile comparison did not reveal a marked similarity, a detailed maintenance requirements

engineering analysis was conducted. Initially, man-hour and parts-usage trends were examined to determine if either parameter increased as a function of time after overhaul, indicating wearout or deterioration. If no increasing trend was evident, it was assumed that the equipment or subsystem could be expected to continue to operate satisfactorily, exhibiting its current maintenance characteristics throughout an extended operating cycle. If an increasing trend was evident, additional analysis was conducted to identify apparent problems and establish the time at which planned restorative maintenance would be required to prevent an unacceptable increase in maintenance burden and downtime.

Detailed analysis was directed toward defining each recurring significant maintenance requirement in terms of several specific factors: the effect of the maintenance action on the subsystem or equipment, the interval between occurrences of the action, the redundancy of the affected subsystem or equipment, the criticality to mission accomplishment, the resources required to perform the necessary corrective maintenance, and the expected subsystem or equipment downtime.

Once the factors associated with the historically required maintenance actions were identified, the individual types of historical maintenance actions were analyzed to identify any design or maintenance-related problems that would have an impact on the selection of a maintenance strategy. Solutions were then sought by examining each problem in relation to the extent to which it was recognized and its amenability to established types of corrective action. These analysis criteria are expressed in the following questions:

- Is the problem known to the Navy technical community, and has a solution been proposed or established?
- Will a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can it be reduced or eliminated by changes to PMS? (These changes might include adding or deleting requirements, changing periodicity, or developing material condition assessment tests and procedures.)
- Can the problem be reduced or eliminated by improving the system's integrated logistic support (ILS) at the ship's force level?
- Can the problem be reduced or eliminated by improving intermediate maintenance activity (IMA) or depot level capabilities?
- Can this problem be reduced or eliminated by revising the existing maintenance strategy?

An affirmative answer to any question resulted in analysis of the effects of the solution and in an estimate, when possible, of the cost to implement the solution. A negative answer prompted the engineer to go to the next question. After all the questions concerning an individual problem were

asked, the alternative solutions were evaluated and the most acceptable alternatives defined and documented as recommendations. These recommended solutions to identified design or maintenance-related problems were then considered during the definition of the maintenance strategy. A further series of implementation recommendations were then formulated to accomplish the objectives of the maintenance strategy selected for the engineered operating cycle (EOC).

2.4 MAINTENANCE PROGRAM DEFINITION

The recommended maintenance program stems directly from the subsystem and equipment maintenance strategies identified by the analysis. The total maintenance program includes both the scheduled and unscheduled preventive maintenance and "engineered" and "qualified" corrective maintenance required to maintain the subsystems and equipments at acceptable levels of material condition and availability over an extended operating cycle. Engineered corrective maintenance comprises those tasks that are well defined and must be accomplished periodically. Qualified tasks are those nonspecific repairs that are likely to be required but cannot be characterized precisely as to nature and frequency.

In development of the implementation recommendations, the results of the analysis were used to identify specific corrective maintenance tasks that would be required periodically. Once these tasks were identified, the frequency of accomplishment, the manpower resources required for accomplishment, and the maintenance level required to perform the work were determined for engineered tasks. Qualified maintenance tasks were also identified, on the basis of historical data, to reserve blocks of man-hours at specified intervals to complete required but nonspecific class C repairs on the subsystems or equipments under analysis.

Where appropriate, additional recommendations were developed for improving subsystem or equipment reliability, availability, and maintainability; system preventive maintenance; logistics support; and IMA or depot level capabilities.

The steps described in this section effectively define the maintenance program recommended for the subsystems and equipments identified for detailed analysis in this ROE. Recommendations resulting from this analysis will be used to develop the class maintenance plan (CMP).

CHAPTER THREE

ANALYSIS RESULTS

3.1 OVERVIEW

This chapter presents the results of an analysis of the corrective and preventive maintenance experiences of selected items of 1200 psi propulsion plant equipments (SWAB group 200) installed on CG-16 and CG-26 Class ships. Included in the analysis were equipments of the main propulsion boilers, the automatic combustion control/main feed pump control/feedwater control systems, the main propulsion turbines, propulsion shafting, combustion air system, condensers and air ejectors, feed and condensate subsystems, circulating and cooling system, the fuel oil service system, and the main lube oil system. Collectively these equipments provide the ship with motive power and the steam required to operate various auxiliary equipments.

These equipments were selected from the Selected Items for Analysis Lists, CG-16 and CG-26 Classes (ARINC Research Publication 1653-06-TR-1875, February 1979) on the basis of their respective contributions to the total class maintenance burden as determined by their individual maintenance burden factor (MBF) rankings. The resulting maintenance burden factors reflect the total annual man-hours devoted to corrective or preventive maintenance of equipments included in a specific SWAB category by the combined ships of the class. A total of 123 and 136 equipments were ranked for the CG-16 and CG-26 Classes, respectively. The ranking of the SWAB categories represents the preventive and corrective maintenance burden contribution of each SWAB category relative to the total class burden. Three categories of information were used to determine this ranking: (1) the ship's force and intermediate maintenance activity (IMA) corrective maintenance man-hour burden (MBF_{CM}) reported in the maintenance data system (MDS), (2) the annual planned maintenance system (PMS) man-hour burden (MBF_{PM}) as determined from equipment maintenance requirement cards (MRCs), and (3) the average number of man-days required for equipment repair during regular overhaul (ROH) as reported in class repair profiles. A summary of these data for the selected 1200 psi propulsion plant equipments is presented in table 3-1, together with their relative corrective and preventive maintenance burden rankings.

Sections 3.2 through 3.11 document the results of the maintenance analyses performed for the selected equipments of the CG-16 and CG-26 Class 1200 psi propulsion plants.

Table 3-1. MAINTENANCE BURDEN SUMMARY FOR SWAB 200 EQUIPMENTS

SWAB Number	CM Burden Rank	PM Burden Rank	Selected Equipments	Class Population	MBF_{CM}*	MBF_{PM}**	CM/PM Ratio	ROH Burden (Man-Days)
			CG-16 CLASS					
221-1, 221-3 and 221-4	2	4	Propulsion Boilers	36	15,125	26,147	.58	5,600
221-2	32	22	ABC System	18	853	4,352	.20	0
231-1	20	23	Propulsion Steam Turbines	18	1,821	4,030	.45	0
243-1	-	-	Propulsion Shafting	18	251	50	5.02	1,165
251-1 and 251-2	17	7	Forced Draft Blowers	72	1,908	14,390	.13	1,812
254-1 through 254-3	28	6	Condensers and Air Ejectors	18	1,173	15,146	.08	0
255-1 through 255-7	3	5	Feed and Condensate System	18	6,507	17,147	.38	1,593
256-1 through 256-3	26	29	Main Circulating Pumps	18	1,222	2,417	.50	254
261-1 through 261-3	15	18	Fuel Oil Service Pumps	36	2,085	5,419	.04	0
262-4	33	25	Standby L.O. Service Pumps	18	835	3,647	.23	171
			CG-26 CLASS					
221-1, 221-3 and 221-4	1	2	Propulsion Boilers	18	23,123	30,738	.75	3,863
221-2	36	21	ABC System	18	1,033	4,906	.21	215
231-1	29	26	Propulsion Steam Turbines	18	1,398	3,928	.36	0
243-1	69	67	Propulsion Shafting	18	25	50	.50	1,139
251-1 and 251-2	31	13	Forced Draft Blowers	72	1,231	10,285	.12	0
254-1 through 254-3	37	7	Condensers and Air Ejectors	18	1,024	14,405	.07	0
255-1 through 255-7	3	8	Feed and Condensate System	18	9,017	13,553	.66	2,468
256-1 through 256-3	22	33	Main Circulating Pumps	18	2,034	2,578	.79	0
261-1 through 261-3	20	22	Fuel Oil Service Pumps	36	2,218	4,815	.46	0
262-4	28	29	Standby L.O. Service Pumps	18	1,432	3,647	.39	204

* This column presents the combined average reported ship's force and IMA corrective maintenance man-hours expended on a particular equipment per year for the entire class population of that equipment.

** This column presents the total required annual PMS hours, as reflected by appropriate MRCs, for the entire class population of that equipment.

3.2 MAIN PROPULSION BOILERS (SWABs 221-1, 221-3, and 221-4)

The main propulsion boilers generate the steam used to drive the main propulsion turbines, the ship's service turbogenerators, the main feed pumps, the forced draft blowers, and all other auxiliary equipments using steam as a prime mover. The CG-16 and CG-26 Class ships are each equipped with four boilers that generate main steam (1,200 psi at 950°F measured at the superheater outlet) and auxiliary steam (1,150 psi at 650°F measured at the desuperheater outlet). CG-19 through CG-24 are equipped with Foster Wheeler (FW) boilers supported by APL 021550077; CG-16, CG-17, and CG-18 are equipped with Babcock and Wilcox (B&W) boilers, supported by APL 021200171. CG-26, -27, -28, -32, and -34 are equipped with B&W boilers, supported by APL 021200176, and CG-29, -30, -31, and -33 are equipped with Combustion Engineering (CE) boilers supported by APL 021450058. Each fire-room has two boilers serving a specific engine room, but cross connections permit operation of any combination of boilers from one boiler cross connected for economical cruising to all four boilers, with the cross connections closed (called split-plant operation) for full-power operation.

3.2.1 Background

Propulsion boilers similar to those installed in the CG-16 and CG-26 Classes are installed in two ship classes that have been previously analyzed in support of the DDEOC Program. These analyses (FF-1052 Class Propulsion Boilers, SMA 101-221; and DDG-37 Class Propulsion Boilers, SMA 37-108-221) showed that boilers in general do not "wear out" in the commonly accepted sense because they have no moving parts. However, they do deteriorate over time because of corrosion, thermal stress, failure of support equipments, and damage resulting from personnel operating errors. Analysis of MDS data, ship visit results, and discussions with the NAVSEC boiler code and NAVSEA (PMS-301) personnel have all led to the common conclusion that most 1200 psi boiler maintenance actions are for the correction of generic problems that are independent of boiler design.

This report section is organized so that each maintenance area is discussed and problems commonly recurring in both classes are presented. Maintenance strategies and implementing recommendations that have been previously identified as solutions to problems common to all boilers are restated in this report where applicable. Maintenance problems in a particular area that have been determined to be unique to a particular CG-16 or CG-26 Class boiler design are also discussed. Specific recommendations are made that are designed to minimize the impact of required maintenance on boiler availability and to improve the overall material condition of boilers throughout the extended operating cycle.

Tables 3-2 through 3-5 present the specific boiler components that have historically required repetitive maintenance and the number of corrective maintenance actions and man-hours reported against each component by CG-16 and CG-26 Class ships and IMA. The following discussions address each of the boiler components listed in the tables.

Table 3-2. SUMMARY OF MDS CORRECTIVE MAINTENANCE REPORTED AGAINST CG-16 B&W BOILERS

Boiler Component	Actions*		Man-Hours			
	Number	Percent of Total	Ship's Force	IMA	Total	Percent of Total
Air Casing	122	17.6	2,435	325	2,760	13.9
Piping	110	15.9	897	1,623	2,520	12.7
Firesides	77	11.1	3,209	15	3,224	16.3
Watersides	105	15.2	2,276	263	2,539	12.8
Stack	31	4.5	808	434	1,242	6.3
Hand Hole	29	4.2	1,262	286	1,548	7.8
Economizer	24	3.5	1,331	483	1,814	9.2
Sliding Feet	17	2.4	74	167	241	1.2
Valve	80	11.5	1,586	579	2,165	10.9
Burner/Register	46	6.6	805	36	841	4.3
Soot Blower	18	2.6	512	1	513	2.6
Gauge Glass	16	2.3	67	0	67	0.3
Safety Valve	14	2.0	171	80	251	1.3
Periscope	4	0.6	74	8	82	0.4
Total	693	100.0	15,507	4,300	19,807	100.0

*Excludes PMS, NSTM, and TYCOM requirements and calibrations, and part ordering for stock.

Table 3-3. SUMMARY OF MDS CORRECTIVE MAINTENANCE REPORTED AGAINST CG-16 FW BOILER

Boiler Component	Actions*		Man-Hours			
	Number	Percent of Total	Ship's Force	IMA	Total	Percent of Total
Air Casing	80	12.0	1,747	1,151	2,898	11.5
Piping	99	14.8	1,877	2,183	4,060	16.0
Firesides	90	13.5	2,816	1,879	4,695	18.6
Watersides	107	16.0	4,666	1,731	6,397	25.3
Stack	40	6.0	610	269	879	3.5
Hand Hole	21	3.1	361	10	371	1.5
Economizer	19	2.8	146	942	1,088	4.3
Sliding Feet	9	1.3	97	40	137	0.5
Valve	94	14.1	1,408	1,303	2,711	10.7
Burner/Register	40	6.0	673	314	987	3.9
Soot Blower	14	2.1	243	21	264	1.0
Gauge Glass	16	2.4	28	1	29	0.1
Safety Valve	39	5.9	276	518	794	3.1
Periscope	0	0	0	0	0	0
Total	668	100.0	14,948	10,362	25,310	100.0

*Excludes PMS, NSTM, and TYCOM requirements and calibrations, and part ordering for stock.

Table 3-4. SUMMARY OF MDS CORRECTIVE MAINTENANCE REPORTED AGAINST CG-26 B&W BOILERS

Boiler Component	Actions*		Man-Hours			
	Number	Percent of Total	Ship's Force	IMA	Total	Percent of Total
Air Casing	72	9.3	2,233	1,426	3,659	10.8
Piping	108	14.3	1,785	4,037	5,822	17.2
Firesides	40	5.3	1,715	2,407	4,122	12.2
Watersides	44	5.8	1,077	1,062	2,139	6.3
Stack	10	1.3	158	115	273	0.8
Hand Hole	52	6.9	1,312	695	2,007	5.9
Economizer	20	2.6	427	1,492	1,919	5.7
Sliding Feet	4	0.5	24	51	75	0.2
Valve	170	22.5	1,981	3,368	5,349	15.8
Burner/Register	63	8.3	1,757	618	2,375	7.0
Soot Blower	38	5.0	1,702	479	2,181	6.4
Gauge Glass	46	6.1	572	178	750	2.2
Safety Valve	86	11.4	1,638	1,457	3,095	9.2
Periscope	2	0.3	8	0	8	<<1
Total	755	100.0	16,389	17,385	33,774	100.0

*Excludes PMS, NSTM, and TYCOM requirements and calibrations, and part ordering for stock.

Table 3-5. SUMMARY OF MDS CORRECTIVE MAINTENANCE REPORTED AGAINST CG-26 CE BOILERS

Boiler Component	Actions*		Man-Hours			
	Number	Percent of Total	Ship's Force	IMA	Total	Percent of Total
Air Casing	115	13.1	4,560	660	5,220	12.0
Piping	86	9.8	3,938	1,388	5,326	12.2
Firesides	58	6.6	8,596	625	9,221	21.1
Watersides	104	11.8	4,871	4,315	9,186	21.0
Stack	18	2.0	205	44	249	0.6
Hand Hole	35	4.0	2,657	50	2,707	6.2
Economizer	17	1.9	196	982	1,178	2.7
Sliding Feet	26	3.0	313	729	1,042	2.4
Valve	72	8.2	903	890	1,793	4.1
Burner/Register	113	12.8	2,122	667	2,789	6.4
Soot Blower	49	5.6	2,154	220	2,374	5.4
Gauge Glass	79	9.0	663	57	720	1.6
Safety Valve	107	12.2	992	877	1,869	4.3
Periscope	1	0.1	1	0	1	<<1
Total	879	100.0	32,171	11,504	43,675	100.0

*Excludes PMS, NSTM, and TYCOM requirements and calibrations, and part ordering for stock.

3.2.2 Air Casing Corrosion

3.2.2.1 Discussion

All three boiler designs have an inner- and outer-casing arrangement providing for the flow of combustion air from inlet ducts at the rear of the boiler through the air registers in the front wall, into the furnace. As shown in tables 3-2 through 3-5, air-casing problems were the most frequently reported subcategory within the CG-16 Class B&W boiler and the CG-26 Class CE boiler, and were fourth in the CG-16 Class FW boiler and the CG-26 Class B&W boiler listing. A total of 389 actions were reported for all boilers for repair of corrosion damage. The man-hour burden associated with the corrosion damage repairs was substantial, as shown in table 3-6, and totaled 14,537 man-hours. Ship's force reported 10,975 man-hours or about 75 percent of total man-hours, and IMAs reported 3,562 man-hours. Most air-casing repairs are accomplished by ship's force with some assistance provided by IMAs. Each repair action averaged 37 man-hours and occurred, on the average, every 14 boiler-months, or about once per year on each boiler. Only one CASREP was submitted for air-casing leaks; the ship involved in that CASREP has B&W boilers. Every ship reported corrosion and deterioration, with the reports divided about evenly between the inner and outer casings. Inner-casing air leakage results in loss of boiler efficiency caused by the cooling effect of the combustion air on boiler heating surfaces. Outer-casing leakage requires higher forced draft blower speed and causes added release of heat into the fireroom.

The B&W boiler data showed repeated reports of corrosion damage concentrated in four areas: around the side wall header, in the rear casing near the superheater door, at the superheater cavity access doors, and in the brick pan. Discussions with the type commander's (TYCOM) boiler inspector confirmed these problem areas and noted that, in the FW boiler, failures frequently occur in the corners of the inner-casing access doorframes at the front of the generating tube area below the economizer tubes. CE boilers had similar deterioration, with a substantial number of reports noting damage to the superheater access doors. These areas should be inspected before BOH and each ROH and should be repaired as shown to be necessary by that inspection and by each ship's CSMP.

An area of air-casing deterioration common to CG-16 and CG-26 Class ships is the bilge boundary skirt, as previously reported in the DDG-37 Class main propulsion boiler review of experience (ROE) (SMA 37-108-221), and the FF-1052 Class main propulsion boiler ROE (SMA 101-221). This area is in a highly corrosive environment; when the skirt is holed by corrosion, bilge water flows under the boiler, where the moisture then causes rusting of headers, structural members and registers. Because of the corrosive environment and the resulting rapid deterioration, the bilge-skirt casing of each boiler should be inspected before each SRA and should be repaired as shown to be necessary by that inspection and by each ship's CSMP.

The TYCOM boiler inspector advised that the most significant problem in FW boiler casing maintenance is corrosion that results when moisture accumulates undetected behind the U-channel covers used to cover the seams

Table 3-6. SUMMARY OF MDS CORRECTIVE MAINTENANCE REPORTED AGAINST ALL CG-16 AND CG-26 CLASS BOILERS

Boiler Component	Actions*			Man-Hours				
	Number	Percent of Total	Average Boiler Months Between Actions**	Ship's Force	IMA	Total	Percent of Total	Average Man-Hours per Action
Air Casing	389	12.6	14	10,975	3,562	14,537	11.9	37
Piping	403	13.0	13	8,497	9,231	17,728	14.5	44
Firesides	265	8.6	20	16,336	4,926	21,262	17.3	80
Watersides	360	11.6	15	12,890	7,371	20,261	16.5	56
Stack	99	3.2	55	1,781	862	2,643	2.2	27
Hand Hole	137	4.4	39	5,592	1,041	6,633	5.4	48
Economizer	80	2.6	>60	2,100	3,899	5,999	4.9	75
Sliding Feet	56	1.8	>60	508	987	1,495	1.2	27
Valve	416	13.4	13	5,878	6,140	12,018	9.8	29
Burner/Register	262	8.5	21	5,357	1,635	6,992	5.7	27
Soot Blower	119	3.8	45	4,611	721	5,332	4.4	45
Gauge Glass	257	8.3	21	1,330	236	1,566	1.3	6
Safety Valve	246	7.9	22	3,077	2,932	6,009	4.9	24
Periscope	7	0.2	>>60	83	8	91	<<1	13
Total	3,096	100.0	2	79,015	43,551	122,566	100.0	40

*Excludes PMS, NSTM, and TYCOM requirements and calibrations, and part ordering for stock.

**Calculated as follows: $\frac{\text{Total Ship Operating Months}}{\text{Number of Actions}} \times \frac{\text{4 Boiler}}{\text{Ship}}$.

between the outer-casing packed panels (see Figure 3-1). The bolted channels should be removed for inspection, the corroded area scaled and represerved, and the covers replaced during BOH and ROH.

One CG-16 Class shipalt and one CG-26 Class shipalt are associated with the air casing. Shipalts CG-16-1184D and CG-26-364D, "Boiler Casing Steam Smothering Supply," provides two-valve isolation of the steam smothering system from the ship's 150 psi steam system and eliminates the necessity to secure the opposite boiler to perform repairs. Completion of the alterations at BOH will enhance each ship's ability to perform boiler casing maintenance while the opposite boiler is steaming, thus permitting distribution of maintenance between steaming and nonsteaming conditions.

The FW boiler technical manual advises checking the casing expansion joint beneath the steam drum for signs of corrosion. Ship maintenance personnel commented on this area also, noting it as a frequent source of leaks. Recent ROH SARPs authorized repair of front and rear steam-drum casing expansion joints on all four boilers. Other ROH repairs routinely authorized for all boiler designs have included the following:

- Replace all missing or stripped boiler casing studs, bolts, and dogs
- Straighten and regasket all inner- and outer-casing access doors (note that straightening access doors for cosmetic purposes was discouraged).

Recurring repairs, although not routinely authorized, have included the following:

- Inspect and renew the brick pan
- Repair deteriorated bilge-skirt casing at the front and at both sides of the boiler (approximately 10 inches high)
- Renew outer rear casing at water drum casing expansion joint

Casing repairs (as listed above) have been routinely authorized or have been recurring because certified boiler inspectors have repeatedly identified substantial casing deterioration. Because air-casing integrity is essential to acceptable boiler performance and crew habitability, these repairs should be routinely scheduled for all ships during BOH and ROH. As discussed above, the bilge-skirt casing should be inspected before each SRA and repaired as shown to be necessary by that inspection and by each ship's CSMP. In addition, to ensure that adequate attention is given to specific air-casing problem areas, the pre-overhaul test and inspection (POT&I) requirements should be revised to highlight the areas of recurring air-casing deterioration.

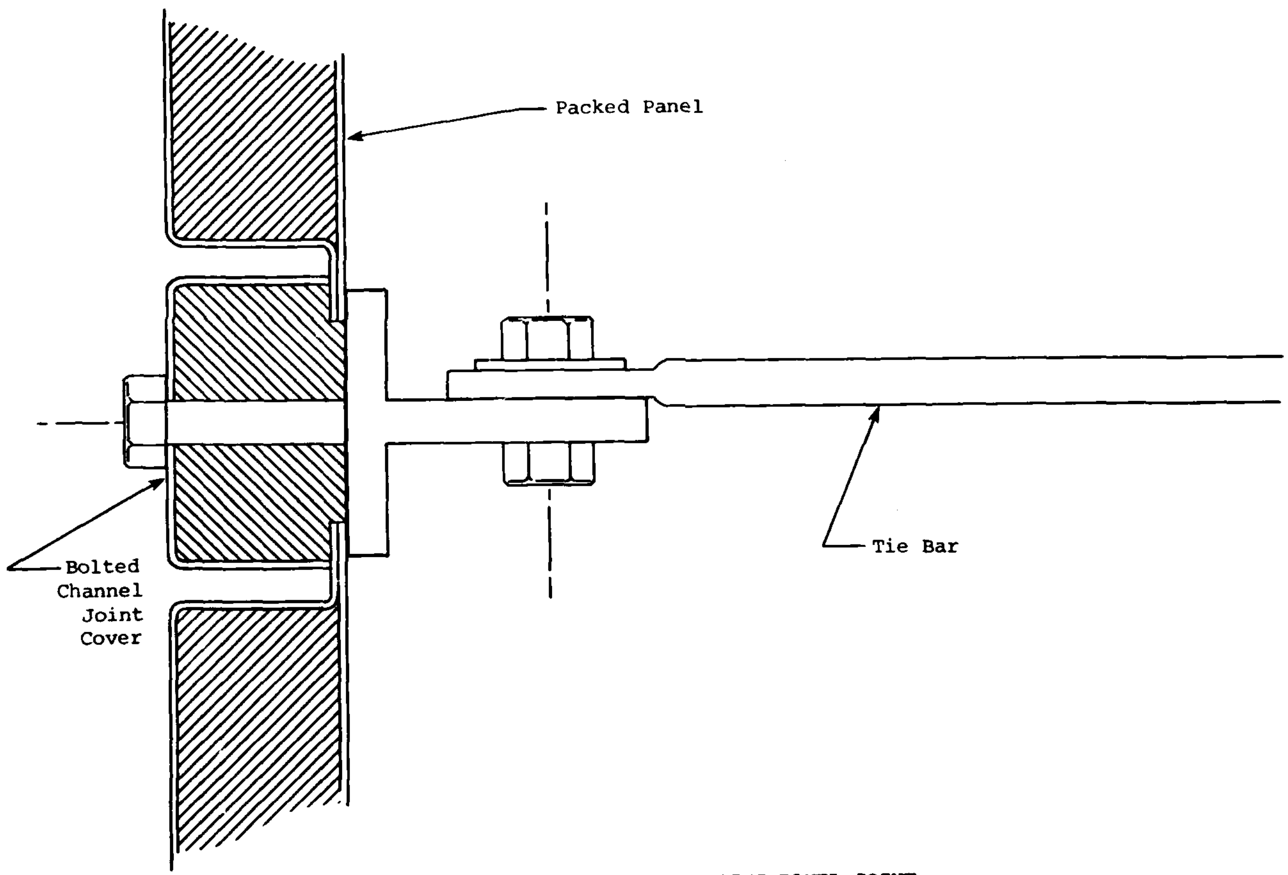

Figure 3-1. FW BOILER AIR-CASING PANEL JOINT

3.2.2.2 Recommendations

It is recommended that the following actions be taken in the boiler casing maintenance area:

- Revise the pre-overhaul test and inspection (POT&I) sheets for boiler inspection before BOH to include specific attention to the following areas of recurring air-casing deterioration:
  - B&W brick pan
  - B&W side wall header
  - B&W rear casing near superheater door
  - B&W superheater cavity access doors
  - FW inner-casing access doorframes at front generating tube area below economizer tubes
  - FW area behind casing joint U-channel covers
  - FW casing expansion joint beneath the steam drum
  - CE boiler superheater access doors and frames
  - Outer rear casing at the water drum-expansion joint
  - Boiler skirt at bilge boundary on B&W, FW, and CE boilers
- Accomplish shipalts CG-16-1184D and CG-26-364D, boiler casing steam smothering supply, during BOH.
- Include a task in the CG-16 and CG-26 Class maintenance plans (CMPs) for a depot activity to accomplish the following repairs during BOH and ROH:
  - Replace all missing or stripped boiler casing studs, bolts, and dogs
  - Straighten and regasket all inner- and outer-casing access doors as determined to be necessary by air test (straightening doors for cosmetic purposes is not recommended)
  - Renew boiler casing skirts
  - Repair deteriorated areas of casing as determined to be necessary by pre-overhaul test and inspection [particular attention should be given to the areas listed in the (revised) POT&I].
- Include a task in the CG-16 and CG-26 CMPs for depot activities to accomplish the following:
  - Inspect the bilge-skirt casing before each SRA and repair it as shown to be necessary by that inspection and by each ship's CSMP
  - Repair boiler casing skirts during ROH as determined to be necessary through air test and inspection

3.2.3 Fireside Maintenance

3.2.3.1 Discussion

Fireside repair accounted for a total of 21,262 man-hours in 265 actions and occurred every 20 boiler-months. Each action averaged about 80 man-hours, which is the highest average repair burden for all reported boiler actions. While fireside corrective maintenance is substantial, the predominant feature in boiler fireside maintenance is the PMS requirement to inspect and clean the firesides following every 1,800 hours of boiler operation. Ship's maintenance personnel indicated that their practice is to inspect the firesides more frequently than required, normally after every steaming period. Changing from Navy special fuel oil (NSFO) to distillate fuel has drastically reduced the fireside maintenance burden; mechanical cleaning is now normally sufficient to remove deposits from the firesides without water washing. Thus the change to distillate fuel, which occurred during the data period, has improved the condition of firesides and reduced the fireside maintenance burden. Because distillate fuel was not used during the entire data period, a portion of the reported maintenance data reflects maintenance resulting from the use of NSFO, which tended to leave more substantial fireside deposits than distillate fuel. As a result, deposit-related fireside failures have decreased, while refractory failures have become more visible.

Review of the B&W boiler MDS narrative data determined that a majority of the fireside maintenance consisted of repairs of refractories, concentrated in the superheater cavity. The front wall was the second most frequently reported fireside maintenance area. In the FW boilers, the refractory failures were evenly distributed among the superheater, front wall, rear wall, side wall, and burner tiles. Burner tile and brickwork damage accounted for a substantial majority of the CE boiler refractory reports. However, no single specific refractory area (such as the front wall) could be identified in the MDS data as the major CE boiler failure area.

Ship's maintenance personnel pointed out that repeated refractory failures have occurred in the B&W boiler superheater support plate where the tubes pass through the front and rear walls of the boiler. The B&W boiler technical manual shows that the original installation called for pouring castable refractory between the superheater tubes. Tube expansion caused early failures of this thin castable refractory. An acceptable alternative repair procedure is described in NAVSEA Repair and Overhaul Manual for 1200 psi Steam Propulsion Plants which explains that Fiberfrax FC-25 can be used in place of the castable refractory as a packing between the tubes. This material will compress under stress from tube movement (rather than crumble and break) and, when installed carefully, has provided satisfactory results. Therefore, when the castable refractory between superheater tubes requires repair, it should be replaced with Fiberfrax FC-25 as described in the NAVSEA repair and overhaul manual.

As noted in the DDG-37 Class boiler ROE, NAVSEC(PHILADIV) personnel agree that the need for major replacement of refractory is best determined by an inspection of the individual boiler firesides. However, their opinion

is that castable refractory will remain in acceptable condition for about five years and firebrick for five to ten years if properly installed. Burner tiles are subjected to stress by the insertion and withdrawal of burners and by temperature cycling, and are expected to survive no more than five years. Castable refractory and all burner tiles should be replaced at BOH and ROH to improve the likelihood that major refractory replacement will not be required during the operating cycle. In addition, shipalts CG-16-1133D and CG-26-315D, shockhardened brickwork, install an improved brickwork anchoring system that provides greater resistance to vibration and shock and reduces refractory replacement. The shipalt documentation specifies that the alterations are to be accomplished when brickwork replacement is required. If brickwork replacement is required at BOH, shipalts CG-16-1133D or CG-26-315D should be accomplished.

A review of SARPs determined that the following refractory repairs have been routinely authorized at ROH: complete renewal of the front wall refractory, renewal of the deck, renewal of Fiberfrax between superheater tubes, and repair of refractory around the superheater access doorframe. As part of the pre-overhaul waterside hydrostatic test and inspection process, the fillets are removed from the side wall and rear wall headers and the water-screen protection refractory is removed. The refractory must therefore be routinely replaced after the test and inspection. In view of NAVSEC(PHILADIV) personnel's opinions that the need for refractory replacement is best determined by inspection, routine accomplishment of these refractory repairs is not warranted. Therefore, specific refractory repairs should be defined on the basis of a boiler inspection by a certified boiler inspector before BOH and ROH. Because of the reported repair history, the POT&I should be improved to highlight the following problem areas for the certified boiler inspector:

- Superheater cavity (B&W and FW)
- Front wall (B&W and FW)
- Superheater support plate (B&W)
- Burner tiles (FW and CE)
- Brickwork (CE)

An allowance for refractory repairs should be established in the CMP, reflecting the man-days expended in previous ROHs but not defining specific repairs until the inspection is complete.

3.2.3.2 Recommendations

In the boiler refractory area, the following actions are recommended:

- Include a task in the CG-16 and CG-26 CMPs for a depot activity to renew all castable refractory and burner tiles at BOH and at each ROH. Include a task for a depot activity to renew other refractories during BOH and ROH as determined to be necessary

by inspection of firesides. If it is determined that total refractory replacement is required, accomplish shipalts CG-16-1133D and CG-26-315D, shockhardened brickwork.

- Revise the POT&I procedure to direct specific attention to those areas where recurring refractory failures occur:
  - Superheater cavity (B&W and FW)
  - Front wall (B&W and FW)
  - Superheater support plate (B&W)
  - Burner tiles (FW and CE)
  - Brickwork (CE)

3.2.4 Sliding Feet

3.2.4.1 Discussion

The boilers are supported at four locations: at each end of the water drum and each end of the side-waterwall header. The rear supports are stationary; sliding feet installed at the boiler front-support points allow for expansion.

The MDS data showed that 36 cases of frozen sliding feet occurred on the CG-16 and CG-26 Class ships; a total of eight actions for CE boilers, nine for FW boilers, and 19 for B&W boilers were reported. An additional 20 actions were reported for greasing and flushing sliding feet and for installing sliding saddle movement indicators. The 56 actions had a reported burden of 1,495 man-hours, or an average of 27 man-hours per repair.

The sliding feet are to be lubricated monthly in accordance with MRC F-1 R-1. The boilers in the ships surveyed, like most boilers, have zerk fittings and a stainless steel tubing arrangement to permit personnel to pump grease into grooves in the sliding feet without entering the boiler casing. It is necessary, however, to station a man inside the casing to verify that the grease is being forced out through the sliding joint at the side opposite the tubing connection. Ship maintenance personnel indicated that they customarily lubricate the sliding feet more frequently than required by pumping grease (without verifying total penetration) while the boiler is steaming. The DDG-37 Class main propulsion boiler ROE recommended installation of a telltale, leading from the far side of the grease groove back to the outside of the casing, so that grease penetration could be verified without entering the casing. Because of the incidence of frozen sliding feet, that recommendation applies also to the CG-16 and CG-26 Classes.

The 1200 psi boiler repair and overhaul manual (NAVSEA 0951-031-8010, see Figure 9-2) presents an example of a sliding saddle movement indicator. The indicator consists of two rods, one attached to the chock facing (which moves with expansion) and the other attached to the nonmoving foundation plate. The rods come out through the boiler casing where their difference in length can be measured (with the boiler either hot or cold) to positively

detect sliding foot movement. The boilers on the two CG-16 Class ships visited had movement indicators similar to those described. MDS narrative data showed that several ships had requested IMA assistance in installing similar indicators. All ships should be fitted with movement indicators, during BOH, if these are not already installed.

The routinely authorized shipyard ROH repairs reported in SARPs included repairing and freeing up sliding feet, renewing the grease line, and installing a movement indicator. When boilers are fitted with movement indicators and positive movement can be observed by ship's forces, it will be unnecessary to routinely authorize freeing up the sliding feet during BOHs or ROHs. Repairs to sliding feet during BOH and ROH should be limited to those identified as necessary in each ship's CSMP.

3.2.4.2 Recommendations

The following actions are recommended:

- Include a task in the CG-16 and CG-26 CMPs for a depot activity to free up any sliding feet during BOH and ROH (by cleaning, flushing, and greasing) where a positive indication of movement is not present.
- At BOH or any prior availability, install sliding feet movement indicators where these are not already installed. This work can be performed by an IMA.
- Provide a telltale for the boiler sliding feet that will give an indication of positive grease flow through the sliding feet. This telltale should be visible from the grease fitting in order to provide positive feedback to the maintenance man.

3.2.5 Waterside Maintenance

3.2.5.1 Background

The MDS data listed in tables 3-2 through 3-6 for watersides are the sum of the number of repairs to tubes, drums, and headers, all of which constitute "watersides". The significant maintenance actions reported against watersides accounted for 16 percent of all the reports against the FW boiler, more than any other maintenance category. Waterside maintenance accounted for 10 percent of the B&W boiler reports and 12 percent of the CE reports. In addition, waterside maintenance accounted for a total of 360 actions that required a total of 20,261 man-hours to complete. Each waterside repair averaged about 56 man-hours and occurred about every 15 boiler-months. The following subsections address waterside maintenance, such as cleaning methods, cleaning intervals, lay-up procedures, historical ROH repair authorizations, and some specific waterside component maintenance problems. Recommendations will be made to define waterside maintenance for extended operating cycles and to propose solutions to the component maintenance problems.

3.2.5.2 Waterside Cleaning

The major factor influencing the maintenance burden of boiler watersides is the requirement to inspect and mechanically clean watersides after every 1,800 to 2,000 hours of boiler operation. Watersides are normally mechanically cleaned with either a high-pressure waterjet or air-motor-driven wire brushes. Acid cleaning may be required to remove hard scale while oil contamination is removed by boiling out the boiler; however, these actions are not considered routine, because they reflect corrective, rather than preventive, maintenance.

In the past, mechanical cleaning was generally performed by ship's force, using expanding wire brushes and air motors. This is an effective method, but it requires the expenditure of a substantial, if not excessive, number of man-hours. Keeping a full inventory of brushes, motors, lubricant, and repair parts on board has been a problem, especially since the brushes must be renewed after the cleaning of 200 tubes.

In recent years, the use of the waterjet cleaning method has become more prevalent. Although it must be performed by an IMA or depot level activity, ships reported little difficulty in scheduling the waterjet cleaning, even when deployed. While the effort expended in preparing the boiler, closing it, and then testing it after cleaning is equivalent to the wire brush effort, the time saved in actual cleaning makes the waterjet method preferable from a morale standpoint. Ship maintenance personnel noted that some waterjet operators miss the top part of the tube by failing to energize the jet until it is three to four inches down in the tube. Cleaning this part of a tube, then, requires "short punching" the upper ends with a wire brush. This problem can be alleviated by emphasizing proper techniques during operator training. Ship maintenance personnel were divided in their preference for wire brushing or waterjetting but confirmed that since the advent of waterjet use, the ability of ship's force to clean watersides by using wire brushes has seriously diminished. Ships commonly lack the necessary wire brushing tools to clean watersides. Therefore, as part of the annual boiler inspection and before BOH and ROH, it should be ensured that the tools necessary to clean tubes mechanically with air-driven expanding wire brushes are on board. This will maintain ship's force capability to accomplish the required cleaning when the waterjet is not available.

3.2.5.3 Waterside Inspection and Cleaning Interval

The FF-1052 and DDG-37 main propulsion boiler ROEs recommended extending the boiler waterside inspection and cleaning interval beyond the current limit of 1,800 to 2,000 operating hours. In the FF-1052 Class ROE, it was suggested that the inspection interval be extended to an annual requirement after the shipalts for the ion exchanger and morpholine injection system were installed. Similarly, the DDG-37 Class ROE recommended extending the interval to some point in the 2,000- to 4,000-hour range on the basis of a post-waterjet cleaning inspection to be accomplished one to three months after BOH.

Discussions with CG-16 Class ship maintenance personnel indicated that in general, they are finding some significant deficiencies (such as soft deposits and linear indications) at the 1,800- to 2,000-hour inspection and would be reluctant to extend the interval with their current feedwater treatment systems. One type commander boiler inspector reported that a recent decision has been made to change the requirement for an annual boiler inspection, which is not related to operating hours, to an inspection every 18 months. There is general acceptance that the alterations adding the morpholine treatment, the demineralizer, and the dissolved-oxygen analyzer will improve the feedwater quality and result in markedly better waterside conditions. There is, however, no CG-16 or CG-26 Class ship in which all of these alterations have been completed and measured for effectiveness. It would be prudent to adopt the approach suggested in the DDG-37 Class ROE which is to install the alterations, operate the ship for three to six months to allow removal of initial deposits, evaluate the effectiveness of the ship's water treatment program, and mechanically clean the watersides by waterjetting. A certified boiler inspector should then inspect the watersides, evaluate the shipalt's effectiveness, and make recommendations to the TYCOM concerning extension of the waterside cleaning interval. The decision to extend the interval between inspections should be made at the TYCOM level.

3.2.5.4 Boiler Lay-Up Procedures

The DDG-37 main propulsion boiler ROE discussed boiler lay-up procedures in detail, including the steam blanket lay-up, the forced-hot-air lay-up, and the hydrazine lay-up. The discussion concluded with two recommendations that are also applicable to the CG-16 and CG-26 Classes. The first was to identify the equipment and procedures necessary to implement a capability for forced-hot-air boiler lay-up in the fleet. The second recommendation was to investigate a hydrazine waterside and forced-hot-air fireside lay-up combination for boilers layed up for up to six months.

A third recommendation appears to be in order on the basis of strong positive information from one ship's boiler maintenance personnel regarding nitrogen lay-up: this recommendation is to initiate a procedure, described in the FW boiler technical manual, to replace the oxygen in the boiler watersides with inert nitrogen. The nitrogen is maintained at about 5 psi. The boiler valves and fittings must be tight to preclude having to replenish large amounts of lost nitrogen. The ship's personnel attribute their success in avoiding nitrogen loss and waterside oxygen pitting to the technique of setting the nitrogen bottle's pressure regulator so that nitrogen is introduced into the boiler while the boiler still has about 25 psi of steam pressure. This prevents entry of oxygen from the atmosphere. The nitrogen lay-up has a distinct advantage in the FW boilers. The superheater tubes have a "W" configuration with a doubled-back portion between the two outside legs that is connected to the superheater headers. Regardless of the direction in which these horizontal superheater tubes are slanted (either toward or away from the headers), there remains a natural trap for water that cannot be effectively drained with a dry lay-up. After using the nitrogen

lay-up, one ship's personnel reported finding no active pitting when watersides were inspected. Further consideration of this lay-up procedure appears warranted because of its advantages in FW boilers. Fleet experience should be reviewed to ascertain actual effectiveness and to determine types and significance of problems encountered when the nitrogen lay-up procedure is being used.

3.2.5.5 ROH Work Authorization

Routine boiler maintenance actions normally authorized for depot level accomplishment during regular overhaul have included the following actions (these have been listed to show the historical maintenance experience of the boilers during ROHs and should not be construed as recommendations):

- Hydrostatic testing at design pressure to identify leaks
- Renewal of defective steam drum mounting studs and steam drum internal fittings
- Renewal of steam and water drum insulation and water drum insulation retainer
- Radiusing and nondestructive testing (NDT) of all superheater nozzles on steam side surfaces
- Hydrostatic testing and nondestructive testing of the desuperheater unit
- Nondestructive testing and repair of the desuperheater inlet and outlet nozzles
- Removal and analysis of a block of generating tubes
- Removal and analysis of a row of superheater tubes from each pass
- Removal and analysis of two rear wall tubes
- Removal and analysis of two screen wall tubes
- Removal and analysis of two side wall tubes
- Provision of a wet lay-up of the boilers between final hydrostatic test and boiler light-off

Ship's forces have normally been required to clean watersides. One TYCOM boiler inspector noted that one shipyard has routinely acid-cleaned watersides before overhaul to avoid late detection of linear indications or other waterside discrepancies. This procedure is not recommended, because the need to acid clean should be determined either by measurement of hard-scale build-up (as part of the sample tube analysis) or by the results of a boiler tube inspection unit inspection (see subsection 3.2.5.6).

3.2.5.6 Boiler Tube Inspection Unit

The boiler tube inspection unit (BTIU), which has been used on a limited basis for some time, has now gained acceptance as a reliable method for inspecting watersides and measuring tube-wall thickness. The unit can

measure wall thickness up to 12 inches into the tube with an ultrasonic transducer. Fiberoptic probes of 18- and 36-inch lengths permit visual inspection of the tube interior wall.

BTIU team members noted excellent results, with only minor limitations. Accurate thickness readings cannot be obtained where tubes are welded to stubs (as in the superheaters) where heavy hard scale exists, or where swaged tubes are used.

Use of the BTIU as part of the pre-overhaul boiler inspection should permit identification of suspect tube areas and a better selection of sample tubes to be removed for analysis. A reduction in the number of sample tubes removed should be possible. Therefore, the BTIU should continue to be used in those tube areas where accurate readings are possible, such as main generating boiler tubes; front, rear, and side wall tubes; and superheater tubes.

3.2.5.7 Boiler Tube Failures

The MDS data indicated that all three boiler designs in both classes experienced tube failures or damage to generating, back wall, side wall, front wall, rear wall, screen wall, and superheater tubes. While there was no concentration of failures in the B&W boilers, failures or damage to superheater tubes predominated in both the FW and CE boilers.

In the FW boilers, 26 of 54 tube-related actions concerned failure or damage to superheater tubes. While no repetitive failure modes were found, the instances of stress-corrosion-caused leakage at the superheater safe-end welds have led to issuance of shipalt CG-16-1170D. This shipalt changes the safe-end weld from its present location in the bent portion of the superheater tube to the straight portion (the safe-end weld joins the chrome-molybdenum superheater tube stud to the chrome-nickel superheater tube). Each tube is shortened and the existing tube stud is replaced by a longer stud, which moves the safe-end weld to the straight portion of the superheater tube. This alteration should be accomplished during BOH on all ships with FW boilers.

CE boiler superheater tubes were involved in 21 of 44 tube-related actions. While no predominant failure mode was evident in the maintenance action narratives, there were several reports of various ruptured tubes, leaks, and plugging and welding of tubes. These reported failures were concentrated in the second and third superheater passes. However, two cases were reported in which tubes in one of the two passes were damaged, presumably by tube failure in the adjacent pass. In addition, several failures were reported in which no reference was made to the superheater pass involved. It is possible that some of these failures can be reduced by accomplishing shipalt CG-26-365D, which specifies replacement of the third- and fourth-pass superheater tubes (2 1/4 percent chrome-1 percent molybdenum) with stainless steel tubes (18 percent chrome-8 percent molybdenum). This shipalt removes the SH36 row tubes (first-row inlet pass) and plugs the same row of the superheater inlet-outlet and intermediate headers. This

shipalt has been completed on two ships and is to be accomplished when the entire superheater bank requires replacement. It should be accomplished on the remaining two applicable ships no later than BOH.

3.2.5.8 External Thinning of FW Boiler Inlet Pass Superheater Tubes

The 1200 psi propulsion plant test procedure noted that limited available information indicates that failures of the FW boiler superheater tubes along the furnace leg adjacent to the rear wall will occur when the remaining wall thickness is approximately 50 percent of specified wall thickness. A close examination for external thinning after 8 to 10 years' service was recommended in the test procedure, on the basis of NAVSECPHILADIV predictions. USS DALE (CG-19) personnel reported ruptured and plugged tubes 7, 8, and 11 in the inlet (S-3) pass in August 1973 and also reported plugged tube 12 in October 1975. These reports occurred about 10 and 12 years, respectively, after commissioning. No cause for the failures was reported. USS REEVES (CG-24) personnel reported that tubes 6, 7, and 8 ruptured in the S-3 and S-4 passes in September 1972, while in January 1973 they reported leaking superheater tubes. It was found that about 8 years after commissioning, the S-3 and S-4 passes were eroded beyond 50 percent wall thickness and were replaced. These MDS data lend support to the NAVSECPHILADIV predictions. In summary, the inlet superheater pass should be closely examined during BOH for external thinning and should be repaired or replaced on the basis of examination results.

3.2.5.9 External Thinning and Internal Pitting of FW Boiler Main Generating Bank Tubes

The 1200 psi propulsion plant test procedure also recommends that tubes in the first four to five rows of the main generating bank be closely examined for a combination of external thinning and internal pitting at approximately 12 to 15 years' service life. Excluding the water-screen tubes, the tubes in question are the LD, LD-1, LE, LF, and LG rows. Two reports of failures in this area were reported: USS DALE (CG-19), after 8 years' service, reported light-to-moderate pitting of the LG-LX rows, where the tube is rolled in the steam drum; USS REEVES (CG-24), after 11 years' service, reported tubes LD-24 and LD-28 leaking at the tube seat in the steam drum. These MDS data tend to confirm the NAVSECPHILADIV prediction. The first four or five rows of the FW boiler main generating bank should be closely examined during BOH for external thinning and internal pitting and should be repaired or replaced on the basis of examination results.

3.2.5.10 B&W Desuperheater Flange Make-Up

Maintenance personnel on ships equipped with B&W boilers reported having difficulty in reinstalling the desuperheater assembly. In the B&W boiler, the desuperheater assemblies are attached to mating drum manifolds with a tongue-and-groove joint. A 0.125-inch, metallic, asbestos, spiral-wound gasket is used in the groove. Ship's personnel noted that they normally ruin four or five gaskets during each reassembly process trying to obtain a good seal; they have also reported instances of damage to the edges

of the tongue-and-groove joint surfaces. Working space around the desuperheater is cramped because the desuperheater is installed in the water drum, and the flanges are at the rear of the drum. Careful alignment and proper makeup of the flanges are critical to ensuring parallel flange faces and correct gasket compression.

The Repair and Overhaul Technical Manual for Main Boilers, 1200 psi Steam Propulsion Plant (NAVSEA 0951-LP-031-8010) shows a flange alignment pin in Figure 5-1. The flange alignment pin is the same length as the stud, is made of carbon steel with a diameter 0.030 inches smaller than the flange-bolt-hole diameter, and has tapered ends to make insertion easier. Use of the flange alignment pin will assist in obtaining a good joint and preventing damage to the tongue-and-groove joint surfaces and the gaskets. Ship's force should be encouraged to make and use a flange alignment pin when reinstalling the desuperheater to reduce the incidence of damage to the desuperheater tongue-and-groove surfaces and to reduce desuperheater reassembly time.

3.2.5.11 Drums and Headers

The number of significant maintenance actions reported under the boiler APLs in the drum and header area accounted for about four percent of the B&W reports, three percent of the FW reports, and seven percent of the CE reports. The deficiencies reported were common to all boiler designs: steam drum internals that were warped, corroded, or would not fit properly and had cracked welds or missing fasteners. Also reported were linear indications and nozzles that had not been radiused. Ship maintenance personnel reported widespread problems after ROH with the fasteners used to secure the steam drum internals. About one-third of the studs and nuts had to be replaced, primarily because they were frozen and had broken off during removal. Inspections and repairs routinely accomplished during ROHs will adequately identify and correct drum and header deficiencies.

3.2.5.12 Feedwater Quality Improvement

In recognition of the critical importance of feedwater quality in maintaining good watersides, the following shipalts have been developed to improve feedwater quality.

- Shipalts CG-16-1086K, CG-26-228K, and CG-26-446D (backfit) install the morpholine condensate treatment system, which minimizes condensate system corrosion by maintaining a mildly alkaline condition in the condensate piping, preventing generation of copper and ferric oxides from the piping.
- Shipalt CG-16-1267D has been established to correct deficiencies in the existing CG-16 Class morpholine injection system. Work requirements for this shipalt are not defined at this time.
- Shipalts CG-16-1244K and CG-26-423K install a demineralizer system in the make-up feed system. These shipalts improve feedwater quality by removing free metallic and nonmetallic ions.

- Shipalts CG-16-1192K and CG-26-464K provide a simplified and reliable method for monitoring dissolved-oxygen levels in the boiler feedwater.

The morpholine condensate treatment shipalts have been completed on all CG-16 B&W ships, three of the CG-26 B&W ships, two of the FW ships, and all CE ships. Ship maintenance personnel have reported satisfactory results following installation. Therefore, accomplishment of these alterations at BOH, where still outstanding, is recommended. Shipalt CG-16-1244K (demineralizer) is not applicable to CG-17 and has not been reported to be complete on any other ship. Shipalt CG-26-423K, the CG-26 Class demineralizer, is still a proposal and has not been issued. It is recommended that these alterations and the associated backfit alteration (shipalt CG-16-1267D) be authorized for accomplishment during BOH. The dissolved oxygen measuring system, shipalts CG-16-1192K and CG-26-464K, has not been installed on any CG-16 or CG-26 Class ships and should be included in the BOH work-list. With the installation of these shipalts and evidence of the expected feedwater quality improvements, it may be possible to extend the waterside cleaning interval (see subsection 3.2.5.3) and thus reduce the boiler maintenance burden.

3.2.5.13 Recommendations

In the area of boiler waterside maintenance, the following actions are recommended:

- As part of the annual boiler inspection and before BOH or ROH, check to ensure that the tools necessary to clean tubes mechanically with air-driven, expanding wire brushes are aboard.
- The following recommendations apply to boiler lay-up procedures:
  - Identify the equipment and procedures necessary to implement a forced-hot-air boiler lay-up capability in the fleet.
  - Investigate a hydrazine waterside and forced-hot-air fireside lay-up for boilers layed up for up to six months.
  - Review fleet experience with the nitrogen lay-up procedures for FW ships and determine their actual effectiveness.
  - Provide a wet boiler lay-up, in accordance with NSTM chapter 221, between final hydrostatic test and boiler light-off.
- Accomplish the following shipalts at BOH:
  - Shipalts CG-16-1086K, CG-26-228K, and CG-26-446D to install the morpholine injection system
  - Shipalts CG-16-1244K and CG-26-423K to install the demineralizer system
  - Shipalt CG-16-1267D to correct deficiencies in the morpholine injection system

- Shipalts CG-16-1192K and CG-26-464K to install the feedwater dissolved oxygen measuring system
  - Shipalt CG-16-1170D to relocate the superheater safe-end welds from the bent to the straight section of the tube stub
  - Shipalt CG-26-365D to replace the CE boiler third- and fourth-pass superheater tubes
- Establish a policy of extending the waterside inspection and cleaning interval on those ships with shipalt-installed morpholine injection systems and ion exchangers. Extension of the waterside inspection and cleaning interval for an individual ship should be decided on the basis of the results of an inspection performed by a certified boiler inspector three to six months following shipalt installation or BOH, whichever is later.
- Include tasks in the CG-16 and CG-26 CMPs for depot activities to accomplish the following at BOH and ROH:
  - Closely examine the FW boiler superheater inlet pass for external thinning and the first four or five main generating bank tube-rows for external thinning or internal pitting during BOH, referencing the 1200 psi propulsion plant POT&I test procedure (221F1010130)
  - Renew defective steam drum mounting studs and steam drum internal fittings; clean the steam drum internals
  - Renew steam drum and water drum insulation and water drum insulation retainer
  - Resurface seating surfaces on manhole covers and in drums
  - Radius and NDT all drum and header nozzles
  - Hydrostatically test, NDT, and repair the desuperheater unit, the desuperheater inlet, and outlet nozzles
  - Conduct a BTIU inspection and remove and analyze rear wall, side wall, generating, superheater, and screen wall tubes, as determined to be necessary
- Encourage ship's force to make and use a flange alignment pin, as shown in Figure 5-1 of the Repair and Overhaul Technical Manual for Main Boilers (NAVSEA 0951LP0318010)

3.2.6 Hand Hole Maintenance

3.2.6.1 Discussion

Hand holes in the boiler headers provide access into the headers for inspection, cleaning, and tube removal and replacement. The hand holes are closed by using a hand hole plate secured with an arch bar, washer, and nut. A spiral-wound flexitallic gasket is inserted between the hand hole plate and the header seating surface.

Parts-usage data in table 3-7 show high replacement rates for hand hole plates and the associated washers, nuts, arch bars, and gaskets. MRC F-1 R-3, the routine inspection of boiler watersides, calls for removal of hand hole plates from the side wall, rear wall, superheater, and economizer headers as part of the inspection process. This routine waterside inspection requirement accounts for the high consumption of gaskets. The other parts were replaced as a result of becoming damaged or lost.

Table 3-7. PARTS USUALLY REPLACED DURING WATERSIDE MAINTENANCE

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
CG-16 Class Foster Wheeler Boiler, APL 021550077						
9Z-5330-00-239-3722	Gasket	-	-	1,034	-	4
9Q-5130-00-260-6025	Brush Refill	29 set	696	42	6.0	2
9Z-5330-00-543-6088	Desuperheater Gasket	-	-	165	-	4
9Z-5330-00-599-5781	Manhole Gasket	2 ea.	48	606	1,262	6
1H-4410-00-773-8165	Hand Hole Plate	28 ea.	672	300	44.6	6
9Z-5330-00-836-3848	Feed Line Gasket	2 ea.	48	21	43.8	4
CG-16 Class Babcock and Wilcox Boiler, APL 021200171						
9Z-5330-00-186-4096	Hand Hole Plate Gasket	2 ea.	24	125	520	3
9Q-5130-00-260-6025	Brush Refill	28 set	336	37	11	2
9Z-5330-00-306-1128	Hand Hole Plate Gasket	107 ea.	1,284	9,275	722	3
9Z-5330-00-599-5781	Manhole Gasket	2 ea.	24	297	1,237	3
9Z-5310-00-637-3630	Manhole Cover Plate Nut	8 ea.	96	129	134	3
9Z-5330-00-684-2885	Desuperheater Gasket	2 ea.	24	157	654	3
1H-4410-00-830-0314	Hand Hole Plate	27 ay.	324	322	99.3	3
1H-4410-00-830-0317	Hand Hole Plate	-	-	82	-	2
1H-4410-00-830-0318	Hand Hole Plate	2 ay.	24	6	24	2
1H-4410-00-830-0319	Hand Hole Plate Arch Bar	82 ea.	984	24	2.4	2
9Z-5310-00-833-2583	Hand Hole Plate Washer	107 ea.	1,284	50	3.9	3
1H-4410-00-830-0318	Hand Hole Plate	80 ea.	960	170	17.7	3
CG-26 Class Babcock and Wilcox Boilers, APLs 021200176 and 021200179						
9Z-5330-00-306-1128	Hand Hole Gasket	1[illegible] ea.	2,180	12,996	596	5
1HM44[illegible]-00-395-3027	Hand Hole Gasket	2 ea.	40	31	78	4
9Z-5330-00-585-9501	Hand Hole Gasket	1 sh.	20	12	60	3
9Z-5330-00-599-5[illegible]81	Manhole Gasket	8 ea.	160	430	269	5
1HM4410-00-830-0314	Hand Hole Plate	27 ay.	540	368	68	5
9Z-5310-00-833-2583	Hand Hole Plate Washer	107 ea.	2,140	95	4	3
1HM4410-00-850-5632	Hand Hole Plate	80 ea.	1,600	150	9	3
CG-26 Class Combustion Engineering Boilers, APL 021450058						
9Z-5307-00-136-2942	Hand Hole Stud Assembly	22 ea.	3[illegible]2	173	49	2
9Z-5330-00-599-5780	Oval Gasket	8 ea.	128	1,985	1,551	4
9Z-5330-00-599-5781	Manhole Gasket	2 ea.	32	355	1,109	4
9ZM5330-00-867-9391	Hand Hole Gasket	72 ea.	1,152	4,149	360	4
1HM4410-00-886-[illegible]777	Stud Cover	48 ea.	768	38	5	3
1HM4410-00-965-9238	Hand Hole Arch Bar	46 ea.	736	7	1	2
1HM4410-00-968-48[illegible]7	Hand Hole Plate	8 ea.	128	186	145	4

The MDS data showed reports of worn or damaged hand hole plates and header seating surfaces in the superheater, side wall, rear wall, and economizer headers. Steam cutting, corrosion, pitting, erosion, and cracking were reported in the MDS narratives. Rounding of the header seating surface shoulder was a common deficiency, as were leaks and frozen nuts. In the aggregate, these failures required corrective maintenance that totaled 137 repairs and 6,633 man-hours, most (5,592 man-hours or 84 percent) of which were reported by ship's force. These repairs averaged 48 man-hours each and occurred an average of every 39 boiler-months. The boiler technical manuals and the repair and overhaul manual provide detailed instructions for installing hand hole plates and caution against excessive tightening in an effort to overcome leaks. Ship maintenance personnel reported instances of excessive force being used in tightening. Following a regular overhaul, one ship reported replacing 35 hand hole plates that were frozen and had to be cut to be removed.

Another possible cause of frozen hand hole plate nuts is failure to use a high-temperature thread lubricant or anti-seize compound. Ship's personnel reported no problems in the use of the compound specified in the boiler technical manual but noted that industrial activities do not always use anti-seize compound when installing hand hole plates.

Leaking hand hole plates are repaired by using various techniques that depend on the nature of the defect. If no seat defect is present, cleaning the seat with a power wire brush fitted with a cup brush may be sufficient. Ship maintenance personnel generally limit their repair efforts to wire brushing. Small defects or a seat taper can be repaired with a seat refacing tool. Localized or generalized pitting or other serious defects require that the seat be either partially or completely rebuilt with weld. Qualified personnel from an IMA or depot generally make any repairs other than wire brushing. Resurfacing of hand hole gasket seating surfaces, as found necessary by a visual inspection, is normally authorized during ROH.

3.2.6.2 Recommendations

It is recommended that all superheater, economizer, side wall, and rear wall header hand hole plates be removed at BOH and each ROH. The hand hole gasket seating surface and the header seating surface should be inspected and repaired as necessary, and all hand hole plate nuts should be reinstalled with an effective anti-seize compound. This task should be included in the CG-16 and CG-26 CMPs for depot accomplishment during BOH and ROH.

3.2.7 Blow and Drain System Piping

3.2.7.1 Discussion

When the significant MDS maintenance action reports against the boiler APLs were segregated into various categories (as shown in tables 3-2 through 3-6), the piping category was found to have one of the highest numbers of actions and man-hours reported of all categories. When the data for the boilers were combined, the bottom-blow system, the superheater drain system,

and the general high pressure (HP) drain systems accounted for more than 50 percent of these reports. The maintenance burden for piping repairs totaled 403 actions and 17,728 man-hours. Each piping repair averaged 44 man-hours and an average of 13 boiler-months elapsed between these repairs.

The bottom-blow system was originally 1 1/2-inch carbon steel piping. The location of the piping in the wet-bilge area subjects it to substantial moisture accumulation and results in severe external corrosion. In the CG-16 Class, a portion of the piping also goes through freshwater tank 6-116-3-W with the same result. The surface- and bottom-blow systems are to be cleaned, inspected, and preserved semiannually in accordance with MRC F-1 S-1. The MRC also requires an ultrasonic test if damage is experienced or the piping integrity is suspect. MDS data showed that ships routinely request the ultrasonic test from the IMAs. A routine hydrostatic test is also specified.

Shipalts CG-16-1261K and CG-26-441K replace the existing bottom- and surface-blow systems with monel piping. The shipalts also specify nondestructive testing and replacement, if necessary, of the header and drum nozzles, redesign of pipe hangars, and relocation of drain lines that discharge on the blow piping. All blow valves are also replaced. Accomplishment of these alterations during BOH will reduce or eliminate the severity of problems in the bottom-blow system. Intracycle and follow-on ROH work should be limited to those blow valve repairs shown to be necessary by inspection, POT&I, and CSMP results.

Ship maintenance personnel reported during interviews that the superheater drain valve manifold and piping are a serious maintenance burden. This report is confirmed by the MDS data that contain frequent reports of leaking and deteriorated superheater-header drain piping and failures of the superheater drain-line steam traps. Shipalts CG-16-1231D and CG-26-271K are designed to provide a nearly maintenance-free drainage system by replacing the superheater high-pressure drain traps with orifice assemblies. The steam traps in the boiler superheater inlet-, outlet-, and intermediate-header drain lines are removed and replaced by an orifice assembly with a strainer/gasket assembly upstream. These shipalts have been completed on seven ships of the class and should be completed on all others no later than BOH to reduce intracycle piping repair.

3.2.7.2 Recommendations

The following actions are recommended:

- Accomplish the following alterations at BOH:
  - Shipalts CG-16-1261K and CG-26-441K, redesigned boiler blow systems, which replaces the existing bottom- and surface-blow systems with monel systems
  - Shipalt CG-16-1231D, superheater/rotating equipment high-pressure drain orifice, which removes the steam traps from the superheater inlet-, intermediate-, and outlet-header drain lines and replaces them with an orifice assembly

- - Shipalt CG-26-271K, high-pressure drain system orifices, which replaces drain-line steam traps with orifices (this shipalt does not replace superheater drain traps).

- Include tasks in the CG-16 and CG-26 CMPs to ultrasonically test the bottom- and surface-blow piping and the high-pressure drain piping at ROH. Repair or replace the piping and valves, as found to be necessary by ultrasonic tests, the pre-overhaul hydrostatic test of the boiler system, and CSMP and POT&I results. Repairs during the intracycle should be limited to those determined to be necessary by inspection and by each ship's CSMP and should be accomplished by an IMA with ship's force assistance.

3.2.8 Uptakes and Stacks

3.2.8.1 Discussion

Maintenance actions in the area of the boiler uptakes and stacks amounted to approximately three percent of all significant reports against the B&W boiler APL, six percent of all significant reports against the FW boiler APL, and two percent of the significant reports against the CE boiler APL. The failures and damage reported included deterioration and holes in the expansion joints; expansion joint drain-piping ruptures, deterioration, and clogging; leaking and deterioration of the outer stacks; and clogged stack drains. Stack repairs totaled 99 actions and 2,643 man-hours, averaged about 27 man-hours per repair, and occurred about every 55 months.

Maintenance personnel and the TYCOM boiler inspectors agreed that the stack and uptake problems have been significantly reduced by utilizing stainless steel uptakes and by burning marine diesel fuel (DFM) instead of Navy special fuel oil (NSFO). However, stack and uptake maintenance are still required because of soot accumulation. Inspection of firesides, rain gutters, and uptake expansion joints is specified by MRC F-1 R-1 after every 1,800 to 2,000 hours of boiler operation. Cleanup of the stack and uptakes at the 1,800-hour fireside inspection is normally easy, but soot clogging of the stack drains still occurs despite the inspections and subsequent cleaning.

Ship's force have been routinely authorized to clean the uptakes, expansion joints, and rain gutters before overhaul. Shipyards have been routinely requested to fabricate a plenum chamber top screen, which protects the forced draft blower intake against any material that may be stored in or may inadvertently enter the plenum. The CG-16 and CG-26 Class DDEOC repair requirements for BOH specify cleaning of uptakes, renewal of the first expansion joint above the economizer, and cleaning and inspection of the uptake drains.

Because soot accumulation and clogging of the stack drains are continuing problems that require repeated cleaning of the stack drains, those repairs currently specified by the DDEOC repair requirements for BOH should be accomplished at BOH and ROH.

3.2.8.2 Recommendations

Tasks should be included in the CG-16 and CG-26 Class CMPs for depot activities to accomplish the following:

- Routinely inspect stack drains for clogging and deterioration at BOH and ROH and clean and repair them as determined to be necessary
- Routinely inspect the stack and uptakes for deterioration at BOH and ROH and clean and repair them as necessary
- Inspect the expansion joints during BOH and ROH and repair or replace them as necessary

3.2.9 Valves

3.2.9.1 Discussion

One of the major maintenance burden areas associated with the main propulsion boiler is valve maintenance, largely because of the many valves installed in the propulsion boiler system. Of the significant maintenance actions reported against the FW boiler, about 14 percent were associated with valve repair. In the B&W boiler, about 17 percent of the significant actions were valve-related, while valve repairs accounted for about 8 percent of the CE boiler actions. A total of 416 valve repairs were reported in the MDS data with an aggregate burden of 12,018 man-hours. This burden is an average of 29 man-hours per repair and an average time between repairs of about 13 boiler-months. The MDS data indicate that repetitive repairs were experienced by most valves, with the reported maintenance concentrated in bottom-blow valves and main steam valves.

3.2.9.2 Bottom-Blow Valves

The most frequently reported problem with bottom-blow valves was leakage; however, there were also reports of unauthorized bonnetless valves in the system and a lack of reach rods to permit valve operation without entering the bilge area. Ship maintenance personnel and the TYCOM boiler inspector reported progress in correcting these problems. It was reported that the correct valves are now available to replace the bonnetless valves. There should be a reduction in the bottom-blow-valve maintenance burden following installation of shipalts CG-16-1261K or CG-26-441K, which replace the blow systems and valves (see subsection 3.2.6). This analysis has already recommended that these equivalent shipalts be accomplished during BOH; the recommendation is therefore not repeated.

3.2.9.3 Main Steam Valves

The CG-16 Class main steam valves are supported by two APLs; the CG-21 has Anchor Equipment Company valves (supported by APL 882042373), while the other CG-16 Class ships have valves made by Walworth Company (supported by APL 882042191). All are 6-inch, 1,500 psi, welded-in-place, gate valves

that use a seal ring to form the seal between the valve body and valve bonnet. CG-26 Class ships also have Anchor Equipment Company valves, supported by APL 882001157. All are 6-inch, 1,500 psi, welded-in-place angle valves. The use of corrugated graphite ribbon packing is authorized for use in all of these main steam stop valves. There were numerous reports in the MDS data of valves leaking through, primarily as a result of cracks in the stellite seating surfaces of the gate and valve seat. However, more than half of the reports cited leaking at the seal ring. Ship maintenance personnel confirmed a problem of inadequate spares support for seal rings, as previously noted in the DDG-37 Class main propulsion boiler ROE. In the process of repairing the valve seating surfaces or the seal ring itself, the IMA and depot level activities must frequently install an oversized seal ring. The IMAs and depots involved with this repair have provided inconsistent documentation support following the repair. Some provide spare oversize seal rings and specify the new seal-ring dimensions, tag the repaired valve indicating that oversize seal rings are required, and help initiate changes to the APL. Other activities do not indicate that an oversize seal ring was used. As a result, when repairs are again required, adequate sizes and quantities of spare seal rings are not available. NAVSEA should develop a policy specifying a procedure to ensure that changes in valve seal rings are properly documented and that the necessary spares support is provided.

3.2.9.4 Welded-In Valves

Ship's force personnel stated that their efforts to repair the valve seating surfaces of welded-in valves are generally limited to lapping. They also stated that IMAs do not repair valves in-place but typically cut them out from the piping and return them to the shop for repairs. A development and training center (DATC)/fleet maintenance assistance group (FMAG) representative confirmed ship's force comments and noted that the valves generally require more extensive repairs than lapping. Because the valve reseating tool is often difficult to set up aboard ship (because of physical interference at the valve locations), in-place repairs have decreased in favor of shop repair. IMAs usually do not consider in-place repair because of poor accessibility of some valves; therefore, the IMAs automatically remove valves from the piping when repairs are required. In many situations, however, access to valves will permit in-place repairs, which can minimize repair time and manpower. Therefore, TYCOMs should emphasize to IMAs that, whenever possible, welded-in valves should be repaired in place rather than automatically cut out and repaired in the shop.

3.2.9.5 BOH and ROH Repair

During BOH and ROH, valves associated with the boilers are checked for leakage as part of the hydrostatic test of the boilers, which normally includes main and auxiliary valves to the bulkhead stops. Specific valve repairs should be authorized for BOH and ROH on the basis of the results of those tests.

Another way of identifying leaking valves, rather than substituting known "tight" valves for valves suspected of leaking, would be to use an

acoustic valve leak detector (AVLD) such as those used by Submarine Maintenance Monitoring Support Office (SMMSO) site teams to identify leaking steam and sea valves in SSBNs. Research studies by the David Taylor Naval Ship Research and Development Center (DTNSRDC) have shown that leaking valves cna be identified when leaks are still small and repairs can be made with the valves in place. Hence, use of the AVLD can yield substantial savings in maintenance time by eliminating valve removals and inspections and can result in material readiness improvements during availabilities, when ship and repair facility personnel can concentrate their often limited maintenance resources on valves that are shown by acoustics tests to be leaking. Published reports indicate that the AVLD has been effective in identifying leaking valves at Norfolk Naval Shipyard and by SMMSO site teams (see references 27, 28, and 29). The use of the AVLD should therefore be expanded to surface ships, especially in the propulsion plant, to identify leaking valves without valve removal and inspection. This could be accomplished by providing AVLDs to DDEOC site teams and to IMAs, and by providing MRCs requiring AVLD testing prior to major availabilities, with valve repairs accomplished on the basis of the test results. Initially, emphasis should be placed on identifying leaks in the blow and main steam systems.

3.2.9.6 Recommendations

The following actions are recommended:

- Tasks should be included in the CG-16 and CG-26 CMPs for the depot to repair during BOH and ROH only those valves known to leak through the seat or seal ring, on the basis of ship's force experience and POT&I and CSMP results.
- A requirement and a specific procedure should be established for intermediate and depot level industrial activities to ensure that changes in valve-seal rings are properly documented and that proper spares support is provided after repair.
- TYCOMs should emphasize to IMAs that, whenever possible, welded-in valves should be repaired in place rather than automatically cut out and repaired in the shop.

3.2.10 Burners and Registers

3.2.10.1 Background

Each of the B&W boilers was originally outfitted with six B&W-modified, Iowa-type oil burners with automatic shut-off valves, supported by APL 300030108. Two of the three CG-16 Class ships with B&W boilers have subsequently had the burners modified by the accomplishment of shipalt CG-16-1094K, vented plunger (VP) atomizer burner installation, with the third programmed to receive it in FY 1979. None of the CG-26 Class ships with B&W boilers has had the equivalent shipalt (CG-26-242K) installed, although the latest available documentation indicates that two ships were programmed to receive installation in FY 1978. The USS BELKNAP is programmed to receive installation as part of its modernization, while the other two ships

with B&W boilers are programmed to receive installation in FY 1980. Each shipalt replaces the return-flow system with a straight mechanical VP burner and reduces the fuel-oil pressure from 1,000 psi to 350 psi.

The Foster Wheeler and Combustion Engineering boilers were originally built with four Todd model LVC-4M burner assemblies per boiler. These return-flow, wide-range atomizer, constant 1,000 psi fuel-oil pressure burners are being replaced with VP atomizer burners by shipalts CG-16-1094K and CG-26-242K. The shipalt is reported completed on two of the six FW ships, with installations on the other CG-16 Class ships programmed for FY 1978 or 1980. Two CG-26 Class ships have received installation of the shipalt, with the other two ships programmed to receive it in FY 1978 and 1980. All installations will probably be completed before the start of any EOCs.

3.2.10.2 <u>Discussion</u>

Maintenance problems reported through MDS were related primarily to the B&W and Todd burners. These reports noted stiffness and difficulty in operation, corrosion, leakage of burner barrels, and deterioration of O-rings. Parts-usage data indicated a heavy demand for O-rings used in both the burner and automatic safety shut-off valve (see tables 3-8 and 3-9). Although there were repetitive burner repairs reported in the MDS during the data period, most of the reports concerned the B&W and Todd burners that will not be installed after BOH because of their replacement with the vented-plunger atomizer burners (VP burners). Accordingly, the MDS data summarized in tables 3-2 through 3-6 and tables 3-8 and 3-9 are not representative of the VP burners' maintenance experience. Because of the limited VP burner data available in the MDS and CASREP system, maintenance data were obtained through discussions with knowledgeable Navy personnel.

Interviews with ship's force personnel and type commander's staff members confirmed the following problems affecting the vented-plunger burners:

- Carbon build-up
- Wearing of burner-centering projections (B&W only)
- Difficulty in maintaining proper burner settings

In addition, there are four burner shipalts outstanding in each class that would improve the operation, safety, and reliability of the burners. All these items are discussed in the following subsections.

3.2.10.3 <u>Carbon Build-Up</u>

Ship's force operating personnel reported that following installation of the VP burner they have experienced incomplete combustion, particularly at low firing rates. They noted carbon build-up and the need to remove heavy clinkers when firesides were inspected. The operators learned to compensate by reducing the number of burners in use at low steaming rates

Table 3-8. CORRECTIVE MAINTENANCE PARTS USAGE SUMMARY FOR SELECTED COMPONENTS OF CG-16 CLASS MAIN PROPULSION BOILERS

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population
NSN	Nomenclature				
Corrective Maintenance Parts for B&W Boiler, APL 021200171					
1H-4410-00-022-9934	Economizer Tube Plug	1 ea.	12	27	225
2H-4410-00-073-9933	Economizer Element	19 ea.	228	6	2.6
2H-4410-00-073-9934	Economizer Element	2 ea.	24	2	8.3
9G-9340-00-292-3749	Burner Observation Window	6 ea.	72	54	75
Burner, APL 300020108					
1H-4530-00-075-0380	Auto Shut-Off Valve	1 ea.	72	1	1.4
9Z-5330-00-171-8068	O-Ring	1 ea.	72	3,130	4,347
9Z-5330-00-196-5381	O-Ring	2 ea.	144	326	226
9Z-5330-00-075-0380	O-Ring	1 ea.	72	213	296
9Z-5330-00-245-8256	Register Gasket	1 ea.	72	114	158
9C-4530-00-906-8098	Sprayer Plate	1 ea.	72	27	3.7
Drum Safety Valve, APL 882170239					
9C-4820-00-036-2053	Disc	1 ea.	24	8	33
Superheater Safety Valve, APL 882170300					
9C-4820-00-036-2047	Disc	1 ea.	12	8	67
Pilot Safety Valve, APL 882170300					
1H-4410-00-757-5082	Disc	1 ea.	12	4	33
Diamond Gauge Glass, APL 450010040					
9C-6880-00-710-9458	Bullseyes	16 ea.	192	63	32.8
Corrective Maintenance Parts for FW Boiler, APL 021550077					
1H-4410-00-268-9831	Burner Observation Window	2 ea.	192	63	32.8
1H-6685-00-585-1236	Gauge	-	-	29	-
Burner, APL 30080087					
9C-4530-00-018-0368	Sprayer Plate	16 ea.	1,536	318	20.7
9C-4530-00-069-6381	Atomizer Assembly	1 ea.	96	67	69.8
9C-4530-00-177-0514	Diffuser	1 ay.	96	94	97.9
9Z-5330-00-196-5385	O-Rings	2 ea.	192	2,228	1,160
9Z-5330-00-810-9659	O-Rings	2 ea.	192	149	77.6
9Z-5330-00-954-7084	O-Rings	2 ea.	192	684	356
Drum Safety Valve, APL 882170247					
1H-4410-00-036-0219	Disc	1 ea.	48	15	31.3
1H-4830-00-163-5176	Safety Valve	1 ea.	48	2	4.2
9C-4820-00-772-6595	Valve Seat	1 ea.	48	9	18.8
Superheater Safety Valve, APL 882170248					
1H-4410-00-757-5087	Spindle and Assembly	1 ea.	24	5	20.8
Pilot Safety Valve, APL 450030017					
9C-4820-00-768-3957	Disc	1 ea.	24	14	58.3
9C-4820-00-931-2134	Nozzle	1 ea.	24	8	-
Yarway Gauge Glass, APL 450030017					
1H-6680-00-897-7788	Glass	14 set	336	438	130

Table 3-9. CORRECTIVE MAINTENANCE PARTS USAGE SUMMARY FOR SELECTED COMPONENTS OF CG-26 CLASS MAIN PROPULSION BOILERS

Part Identification: NSN	Part Identification: Nomenclature	Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced To Total Population	Number of Ships Reported
Babcock and Wilcox Boilers, APLs 021200176 and 021200179						
1HM4410-00-022-9934	Economizer Tube Plug	4 ea.	80	25	31	5
9G-9340-00-292-3749	Burner Observation Window	6 ea.	120	105	80	3
1H-6685-00-399-3236	Bezel	-	-	104	-	3
1H-6685-00-526-6357	Gauge	-	-	8	-	2
1H-6685-00-908-2413	Gauge	-	-	10	-	2
Burner, APL 300020108						
1HM4530-00-075-0380	Auto Shut-Off Valve	1 ea.	170	12	10	4
9C-4820-00-080-5572	Gasket	-	-	607	-	3
9C-4530-00-152-1030	Sprayer Plate	-	-	140	-	3
9Z-5330-00-171-8068	O-Ring	1 ea.	120	2,133	1,778	5
9Z-5330-00-196-5381	O-Ring	2 ea.	240	359	150	5
9Z-5330-00-231-3261	O-Ring	1 ea.	120	294	245	5
9Z-5330-00-245-8256	Register Gasket	1 ea.	120	121	101	4
9C-4530-00-736-9228	Sprayer Plate	-	-	57	-	2
9C-4530-00-736-9255	Sprayer Plate	-	-	38	-	2
9C-4530-00-906-8099	Sprayer Plate	-	-	12	-	2
Drum Safety Valve, APL 882170312						
1HM4410-00-036-0219	Valve Disk	1 ea.	40	9	22	5
Superheater Safety Valve, APL 882170311						
1HM4410-00-036-0219	Valve Disk	1 ea.	20	5	25	3
1HM4410-00-757-5084	Valve Seat	1 ea.	20	4	20	2
1HM4410-00-757-5087	Spindle Assembly	1 ea.	20	4	20	2
1HM4410-00-757-5088	Adjusting Ring	1 ea.	20	2	10	2
Combustion Engineering Boilers, APL 021450058						
9C-4820-00-081-5943	Gauge	-	-	17	-	2
1HM3456-00-640-3172	Roller Mandrel	1 ea.	16	24	150	2
1HM3456-00-640-3175	Roller Mandrel	-	-	22	-	2
1HM3456-00-640-3313	Roller Mandrel	1 ea.	16	24	150	2
1HM3456-00-640-3314	Roller Mandrel	1 ea.	16	24	150	2
Burner, APLs 300080094 and 300080095						
9C-4530-00-018-0363	Sprayer Plate	1 ea.	96	40	42	4
9C-4530-00-018-0366	Sprayer Plate	1 ea.	96	70	73	4
9Z-5330-00-132-6970	O-Ring	-	-	248	-	2
9C-4530-00-177-0514 / 9C-4530-00-394-8472	Burner Diffuser	1 ay.	96	116	121	4
1HM4410-00-268-9831	Observation Window	2 ea.	192	79	41	3
9Z-5330-00-171-9916	O-Ring	-	-	301	-	3
9Z-5330-00-196-5379	O-Ring	-	-	68	-	3
9Z-5330-00-196-5385	O-Ring	-	-	230	-	2

(Continued)

Table 3-9. (Continued)						
Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
Burner, APLs 300080094 and 300080095 (continued)						
9Z-5330-00-202-1061	O-Ring	1 ea.	96	150	156	3
9G-4530-00-736-9223	Sprayer Plate	-	-	153	-	4
9Z-5330-00-810-9659	O-Ring	2 ea.	192	358	176	4
9Z-5330-00-864-7182	O-Ring	-	-	104	-	3
9C-4530-00-897-2967	O-Ring	-	-	25	-	3
9C-4530-00-900-8346	Sprayer Plate	-	-	102	-	4
9Z-5330-00-954-7084	O-Ring	2 ea.	192	955	497	4
9Z-5330-00-973-0615	O-Ring with Retainer	6 ay.	576	565	98	4
9Z-5330-00-995-7139	O-Ring	-	-	740	-	4
Drum Safety Valve, APL 882170292						
1HM4410-00-036-0219	Valve Disk	1 ea.	32	25	78	3
1HM4410-00-070-9447	Spindle Assembly	1 ay.	32	9	28	3
1HM4410-00-757-5084	Valve Seat	1 ea.	32	16	50	4
Superheater Safety Valve, APL 882170291						
9C-4820-00-016-0231	Spring and Washer	1 ea.	16	4	25	2
1HM4410-00-036-0219	Valve Disk	1 ea.	16	14	88	3
1HM4410-00-757-5084	Valve Seat	-	-	5	-	3
1HM4410-00-757-5085	Ring	1 ea.	16	2	12	2
1HM4410-00-757-5086	Disk Holder	1 ea.	16	4	25	2
1HM4410-00-757-5087	Spindle Assembly	1 ea.	16	10	62	5
1HM4410-00-757-5088	Adjusting Ring	1 ea.	16	2	12	2
Components Common to All CG-26 Class Boilers						
Superheater Pilot Safety Valve, APL 882170293						
9C-4820-00-011-6294	Disk Holder Assembly	1 ay.	36	14	39	6
1HM5220-00-036-0302	Seat Gauge	1 ea.	36	6	17	3
1HM4410-00-399-2559	Spring and Washer	1 ay.	36	11	30	4
1HM4820-00-605-7877	Lapping Block	-	-	6	-	3
9C-4820-00-768-3957	Valve Disk	-	-	54	-	9
9C-4820-00-862-9412	Adjusting Ring - Lower	1 ea.	36	15	42	3
9C-4820-00-862-9414	Valve Guide Assembly	1 ay.	36	14	39	4
9C-4920-00-862-9415	Adjusting Ring - Upper	1 ea.	36	13	36	5
9C-4820-00-862-9416	Spindle Assembly	1 ay.	36	47	130	8
1HM4410-00-969-0043	Valve Nozzle	-	-	23	-	5
Boiler Water Level Indicators, APLs 450030015 and 450030014						
9G-6680-00-049-8008	Glass	4 ea.	144	23	16	5
9G-6685-00-798-5485	Shield Assembly	4 ea.	144	744	517	9
9Z-5330-00-798-9115	Gasket	4 ea.	144	785	545	9
1HM6685-00-799-5474	Gauge Glass	-	-	616	-	9
9Z-5306-00-953-0262	Cap Screw Assembly	48 ea.	1,728	548	32	8

in port and raising the fuel-oil pressure to a minimum of 125 psi. This technique defeats the purpose of the VP burner shipalt, which is to permit firing all burners through the full range of steam demand.

According to correspondence from the Naval Ship Engineering Center, Philadelphia Division (NAVSECPHILADIV), several ships operating with the VP atomizer burner system have reported carbon build-up on burner throats. It has been determined that this build-up is the result of burner sensitivity to operating parameters such as air flow and burner settings. NAVSECPHILADIV has developed a new orifice plate which, in limited shipboard testing, has shown promise of eliminating the carbon build-up. A significant improvement in performance was noted through comparison of carbon build-up in boilers equipped with the new orifice plate with boilers equipped with conventional orifice plates during a short ship transit. Further testing in an operational shipboard environment is planned.

3.2.10.4 Wearing of Burner Centering Projections

Discussions with ship maintenance personnel indicated that a problem exists with wear of centering projections on the burner barrel. There are three 1/16-inch projections, spaced at 120° intervals around the barrel circumference and 2 5/8-inches from the furnace end of the barrel. The projections, which serve to keep the barrel centered in the distance piece, are made by building up weld on the barrel. As the projections wear, the barrel becomes misaligned and the flame pattern is distorted. This misalignment becomes more critical when the VP burner shipalts are installed and can aggravate carbon build-up (as discussed above). Ship's personnel reported that they were unable to reweld the projections and were systematically changing the old barrels by procuring replacements. The projections are 1/16-inch high and welded on the barrel. Because of cost differentials, restoring the barrel projections by weld build-up would be preferable to wholesale routine barrel replacement and could feasibly be accomplished at either IMA or depot level activities. Ship's force is required to inspect burner barrels in conjunction with the 1,800-hour fireside inspection by MRC F-1 R-15. The barrel projection dimensions should be checked during this inspection to determine the amount of wear. Therefore, a note requiring a check of the centering projection dimensions should be added to MRC F-1 R-15. The dimensions of the barrel projections should also be checked at BOH and the ROH and repairs made as necessary. When possible, the barrels should be repaired rather than replaced, because of the cost differential between repair and replacement.

3.2.10.5 Burner Shipalts

Table 3-10 lists the burner-related shipalts outstanding on certain ships of the CG-16 and CG-26 Classes. A description of each shipalt is presented in the following paragraphs.

Shipalts CG-16-1094K and CG-26-242K reduce fuel system pressure from 1,000 psi to 350 psi, thereby reducing fuel pump power requirements and fuel-pump load. Gas entrainment in the fuel system is eliminated and the

Table 3-10. BURNER-RELATED SHIPALTS FOR CG-16 AND CG-26 CLASSES		
Shipalt Brief	Shipalt Number	
	CG-16 Class	CG-26 Class
1. Vented Plunger Atomizer Burner	1094K	242K
2. Fuel Oil System Remote Shutdown Improvement	1113K	231K
3. Replacement or Relocation of Fuel Oil Micrometer Valves	1271D	455D
4. Burner Light-Off Door Relocation	1297D	460D

fuel-oil coolers are removed. The new system uses a direct-flow vented plunger burner, negating the need for the return system, which is removed.

Shipalts CG-16-1113K and CG-26-231K install improved fuel-oil quick-closing valves that have internal pressure equalization. The quick-closing valves on the boiler fronts are eliminated and the remote-operation/valve-closure stations are installed at the upper and lower firing aisles and at the boiler control station. A quick-closing valve is also installed in the steam supply line to the fuel-oil service pumps.

Shipalts CG-16-1271D and CG-26-455D replace and relocate the fuel-oil micrometer valves. Where the VP burner modification has been completed, a new micrometer valve is installed. Where the VP burner modification has not been completed, the existing micrometer valve is removed and replaced with a gate valve and bypass. These shipalts are to be accomplished only during or after VP burner installation; they permit fuel-oil system maintenance without securing fuel-oil flow to the boiler.

Shipalts CG-16-1279D and CG-26-460D relocate the light-off port from its original location (adjacent to burner number 5) to below and between burners 1 and 4. The new location is intended to increase superheater life by permitting use of the burner farthest from the superheater during light-off.

Shipalts CG-16-1094K and CG-26-242K, VP burners, and shipalts CG-16-1113K and CG-26-231K, improved fuel-oil quick-closing valves, are safety-related and should be installed no later than BOH. Installation of the other shipalts during BOH should be considered because of their expected contributions to improving maintainability and reliability.

3.2.10.6 BOH and ROH Requirements

A common practice during ROH has been to overhaul air registers and burner housings in accordance with TRSs 0221-086-628 (B&W), 0221-086-629 (CG-16 Class Todd), or 0221-086-633 (CG-26 Class Todd), and test them in accordance with the 1200 psi test and certification test procedure. Recent SARPs specify that burners are to be repaired in conjunction with the accomplishment of shipalts CG-16-1094K and CG-26-242K. These overhauls and repairs have been completed because of the importance of the register and burner housings and because of the recurring requirement for repairs. Therefore, these repairs should be accomplished at BOH and ROH. Repairs during the cycle should be made as determined to be necessary by PMS fireside inspections.

3.2.10.7 Recommendations

The following actions are recommended:

- Continue current NAVSECPHILADIV efforts to resolve the carbon buildup problem with the VP burners at low steaming rates and include an extensive shipboard-testing period.
- Investigate the feasibility of restoring burner centering projections by rewelding at the IMA or depot level. Add a note to MRC F-1 R-15 to check the burner projections when inspecting burner barrels. Check the projection dimensions at BOH and ROH and repair as necessary.
- Include tasks in the CG-16 and CG-26 CMPs for depot activities to overhaul the burner housings and air registers at BOH and ROH, in accordance with TRSs 0221-086-628 (B&W), 0221086-629 (CG-16 Class Todd), or 0221086-633 (CG-26 Class Todd), and test them by using the 1200 psi test procedure. Make those repairs to burners and shut-off devices at BOH and ROH shown to be necessary by POT&I, CSMP, or fireside inspection results. These repairs can be performed in conjunction with the installation of the VP burner shipalt.
- Accomplish the following burner-related shipalts in accordance with the steam propulsion plant improvement program schedule, but not later than BOH:
  - Shipalts CG-16-1094K and CG-26-242K to install vented-plunger (VP) atomizer burner
  - Shipalts CG-16-1113K and CG-26-231K to improve fuel oil system remote shutdown
- Consider installing the following shipalts at BOH:
  - Shipalts CG-16-1271D and CG-26-455D to replace/relocate fuel oil micrometer valves
  - Shipalts CG-16-1279D and CG-26-460D to relocate burner light-off door

3.2.11 Safety Valves

3.2.11.1 Background

CG-16 Class ships with B&W boilers were outfitted with Consolidated huddling-chamber type safety valves. There are four safety valves for each boiler:

- One 1 1/2-inch pilot-actuator safety valve, type 1711-P-5, supported by APL 882170300
- One 2 1/2-inch superheater unloading valve, type 1711-U, supported by APL 882170241
- Two 2 1/2-inch drum valves, type 1553, supported by APL 882170239

The CG-16 Class FW boilers and CG-26 Class B&W boilers are protected by four Crosby nozzle-reaction type safety valves:

- One 1 1/2-inch pilot-actuator safety valve, style HN P-F, installed on the drum and supported by APL 882170298 (CG-16) and by APL 882170293 (CG-26)
- One 2 1/2-inch superheater unloading valve, style HN B-J, located in the superheater outlet piping and activated by the pilot-actuator safety valve, supported by APL 882170248 (CG-16) and by APL 882170311 (CG-26)
- Two 2-1/2-inch drum safety valves, style HN-J, supported by APL 882170247 (CG-16) and by APL 882170312 (CG-26)

The CG-26 Class CE boilers are also protected by four Crosby safety valves:

- One 1 1/2-inch pilot-actuator safety valve, style HN P-F, installed on the drum and supported by APL 882170293
- One 2 1/2-inch superheater unloading valve, style HN B-J, located in the superheater outlet piping and activated by the pilot-actuator safety valve, supported by APL 882170291
- Two 2 1/2-inch drum safety valves, style HN-J, supported by APL 882170292

All of the Crosby safety valves of a given style are identical and are discussed with the Consolidated safety valves in the following subsections.

3.2.11.2 Discussion

The MDS data indicated that a ship's force and IMA intracycle man-hour burden of about three man-hours per valve per operating year was reported against the safety valves, with the effort expended about equally divided between ship's force and IMA personnel. A total of 246 repair actions and 6,009 man-hours were reported during the data period, for

an average of about 24 man-hours per repair and an average time between repairs of about 22 boiler-months. The most frequently reported problems requiring repair were bent valve spindle and valve leak-through.

3.2.11.3 Bent Valve Spindle

The bent valve spindle is recognized as the main cause of erratic safety valve operation. The most frequent cause of a bent spindle is overgagging (applying excessive pressure when installing gags). The safety valves are gagged when they are being tested or when safety valves are being set with different set points on the same boiler, when the safety valve nozzle ring is being adjusted during boiler operation, and when the boiler is hydrostatically tested above maximum operating pressure. When the 150 percent hydrostatic test is performed, the safety valves are removed and blank flanges are installed. At hydrostatic test pressures between 100 percent and 150 percent, safety valve gags may be used. However, the use of blank flanges is recommended to prevent bending the valve spindles. The MRC that governs testing of safety valves by steam (MRC F-1 R-3) cautions against using a wrench to tighten gags. As reported in the DDG-37 Class main propulsion boiler ROE, a new type of gag with a machined-surface fit and a self-aligning feature has been designed to reduce the incidence of bent spindles. This new gag should be provided to all ships, with appropriate changes made to the technical manuals.

3.2.11.4 Valve Leak-Through

There is an inverse relationship between the lifting pressure and the maintenance burden associated with the safety valve types; the pilot-actuator safety valve lifts first at 1,375 psi (it had the highest maintenance burden), followed by the superheater unloading valve at 1,375 psi, and the two-drum safety valves at 1,400 and 1,415 psi (see table 3-11 for a presentation of this relationship). This relationship results from two factors: first, the lower pressure valves need to be gagged more often, increasing the chances for overgagging and bent valve spindles; second, repeated lifting, experienced more by the lower-pressure valves than the higher-pressure valves, results in wear, steam cutting, and valve leak-through.

MRC F-1 R-3 specifies the proper lifting and reseating pressure for each safety valve. The lifting pressure is given with a ± 10 psi tolerance. A specific reseat pressure is given with the note that reseat points are considered satisfactory at any point between three and six percent below lifting pressure, provided that the valves seat in proper sequence. These requirements provide a significant range of allowable settings. Every effort should be made to attain settings at any point within the full range with two or three liftings, since repeated lifting contributes to safety valve leakage. This point can be emphasized by adding a note to step 10 of MRC F-1 R-3 (MIP F-1/37-96) to read: "Excessive lifting of safety valves contributes to valve leakage; attempt to accomplish all adjustments within two or three lifts."

Table 3-11. SAFETY VALVE CORRECTIVE MAINTENANCE BURDEN BY LIFTING PRESSURE

Safety Valve Type	Nominal Lifting Pressure (psi)	Safety Valve Corrective Maintenance Burden (Man-Hours per Component per Operating Year)			
		CG-16 Class		CG-26 Class	
		B&W	FW	B&W	CE
Pilot-Actuator Safety Valve	1,375	3.8	3.5	7.1*	7.1*
Superheater Unloading Safety Valve	1,375	1.4	2.0	4.8	6.0
Drum Safety Valve	1,400/ 1,415**	0.3	1.8	2.8	2.4

*The same APL supports the superheater pilot safety valves installed on B&W and CE boilers. Therefore, the table lists the burden reported against the APL rather than the valve installed on each boiler design.

**The first drum safety valve lifts at 1,400 psi and the second at 1,415 psi.

The MDS data showed that valve discs experienced the highest repair-part usage for each of the safety valves. The boiler technical manual provides detailed procedures for disassembly, inspection, remachining of seat bushing, grinding and lapping of seats and discs, and reassembly. It is stated that normal damage to the bushing seat can be repaired by hand lapping; severe damage can be repaired by remachining. Normally, disc damage can also be repaired by using a hand lap, although severe damage requires disc replacement. Ship maintenance personnel indicated that their on-board efforts are generally limited to grinding in seats and discs with grit compound, with the work being performed by only the most experienced personnel. Safety valves are tested and inspected at approximately six-month intervals, in conjunction with the PMS-required waterside inspection. It is concluded that since the reported intracycle man-hour burden was low and the repairs reported were generally within ship's force capability, little major safety valve maintenance will be required between ship overhauls during DDEOC.

Review of regular overhaul SARPs showed that the safety valves are normally given a complete overhaul during ROH. Disassembly, replacement of defective parts, reassembly, test, and setting of lifting and reseating pressures are routinely authorized, at a cost of $1,200 to $1,500 per safety valve. Ship maintenance personnel and the SURFPAC TYCOM's

boiler inspector, when questioned, did not provide a rationale that justified routine overhaul of all safety valves. As discussed in the DDG-37 Class propulsion boiler ROE, indications are that routine overhaul of safety valves does not necessarily result in better safety valve operation than before overhaul. At a minimum, the spindles and seating surfaces should be inspected to ensure reliable operation. There is one note of caution in not requiring class B overhauls during ROH. If left on the boiler, safety valves are subject to damage from grit, chemicals, and corrosion. Hence, if only spindles and seats are to be repaired, safety valves should still be removed from boilers (rather than repaired in-place), repaired, and stored during ROH to prevent damage.

The MDS data and absence of any CASREPs during the intracycle period indicate no maintenance-driven requirement for routine overhaul of all safety valves. It is concluded that the practice of routine overhaul is based upon the criticality of the safety valves for protection of the boiler and operating personnel and is an "insurance" type repair. As previously stated in the DDG-37 Class main propulsion boiler ROE, the BOH and ROH repair should specify removal of the safety valves and inspection for bent spindles, seat damage, and wear or damage to other parts. The extent of the repairs (including overhaul, if necessary) should be determined by results of the inspection, the POT&I, and each ship's CSMP, rather than by the authorization for routine overhaul of all safety valves.

3.2.11.5 Recommendations

The following actions are recommended for boiler safety valves:

- Provide each ship with the new, improved, self-aligning safety valve gag. Make appropriate changes to the safety valve APLs and the technical manuals.
- Change MRC F-1 R-3 of MIPs F-1/33-96, F-1/57-58, F-1/90-47, F-1/122-96, F-1/194-77, and F-1/196-78 (all of which cover testing safety valves by steam) by adding the following sentence: "Excessive lifting of safety valves contributes to valve leakage; attempt to accomplish all adjustments with two or three lifts."
- Include tasks in the CG-16 and CG-26 Class CMPs for depot activities to remove and inspect the safety valves at BOH and ROH and to repair them as shown to be necessary by the results of disassembly and inspection, POT&I, and CSMP. They should be tagged and stored after repair and reinstalled later in the availability in preparation for the light-off exam (LOE).

3.2.12 Soot Blowers

3.2.12.1 Discussion

The B&W main propulsion boilers are equipped with Diamond model G9B soot blowers, which clean the external surfaces of the generating, superheater, and economizer tubes. There are six rotating elements, with APLs

813020074 and 813020075 assigned to the CG-16 Class and APLs 813020208 and 813020209 assigned to the CG-26 Class, and two stationary elements with no APL assigned.

Nine Copes-Vulcan PN-3 rotary soot blowers and two stationary units were originally installed on the FW boilers. When replacement was required, the obsolete PN-3 heads were removed and Copes-Vulcan DN-4 heads were installed in accordance with shipalt CG-16-1205D. The PN-3 heads were supported by APL 813030041; the DN-4 heads are supported by APL 813030052.

Combustion Engineering boilers have one retractable, one stationary, and five rotary soot blowers, manufactured by Copes-Vulcan. As with the FW boilers, the soot-blower heads are DN-4 models. The rotary soot blowers are supported by APL 813030048; the retractable soot blower is supported by either APL 813030049 or APL 813030078. There is no APL for the stationary soot blower. The soot blowers are supplied with 1,200 psi desuperheated steam, reduced to 150 psi for the stationary units and 300 psi for the rotating units.

Soot blowers experienced a relatively low MDS maintenance burden when compared with other boiler areas. There were 119 repair actions reported in the MDS, with a total of 5,332 man-hours reported. One action that reported major soot blower drain repairs accounted for 1,201 man-hours (22 percent) of this total and is considered to be a unique repair, not typical of the normal soot blower maintenance experience. No significant repetitive parts usage was experienced. IMA or depot level assistance is normally required for ultrasonic testing of the soot blower heads and piping. Because of potential safety hazards, a discussion of soot blowers is presented in the following subsections.

3.2.12.2 Soot Blower Operating Pressures

A potential safety hazard exists in the performance of MRC F-1 A-2, the requirement to test soot blower operating pressures. The MRC does not provide for use of a loop (charged with water) in the gauge line to the test connection to prevent pressurizing the gauge with live steam. The high-pressure steam could rupture the gauge and cause personnel injury. A note should be added to the MRC to warn personnel of the possible safety hazard and to describe a method of safely measuring the operating pressures.

Ship maintenance personnel expressed concern (confirmed by the TYCOM's boiler inspector) about a recurring problem in completing the PMS requirements to test and adjust blowing pressures on the Copes-Vulcan soot blowers. The test-pressure gauge is installed in the air-valve hole by removing a 3/8-inch stainless steel pipe plug. The plugs frequently freeze in the body and are difficult to remove because the threads become galled. Retapping is often required. The problem can be corrected by the conscientious use of a light coating of anti-seize compound on the pipe plug threads as called for in the technical manual and the MRC.

3.2.12.3 Two-Valve Root Steam Protection

Shipalts CG-16-0145D and CG-26-096D install a second root valve in series with the existing root steam valve to the soot blowers to provide two-valve protection during boiler soot-blower maintenance. The shipalt is reported completed on all ships in the CG-16 Class (except CG-17) and all ships in the CG-26 Class (except CG-26 and CG-27). For safety reasons, the shipalts should be accomplished on CG-17, -26, and -27 no later than BOH.

3.2.12.4 ROH History

During ROH, typical authorized repairs have included ultrasonic testing of the soot-blower heads and piping (with repairs and replacements made as necessary), overhaul of the soot-blower heads, setting of the blowing arcs and pressures, and operational test of the soot blowers. These tasks are adequate to restore the soot blowers to acceptable operating condition and should therefore be accomplished during BOH and ROH.

3.2.12.5 Recommendations

The following actions are recommended for soot blowers:

- Change MRC F-1 A-2 of all MIPs F-1/XXXX as follows:
  - After step 1b, which reads, "Remove pipe plug from test connection", insert "Warning: Do not allow live steam to pressurize the test gauge. This could result in rupture of the gauge and possible personnel injury."
  - Change step 1c to read, "Prepare a test-pressure gauge with 0 to 600 psi range and 3/8-inch fittings. Make a loop in the gauge hose and charge the loop with water. Install the test gauge in the test connection."
- Accomplish shipalts CG-16-0145D and CG-26-096D, "Boiler Soot Blower Piping Modifications," no later than BOH on CG-17, CG-26, and CG-27.
- Include tasks in the CG-16 and CG-26 Class CMPs for depot activities to accomplish the following work at BOH and ROH:
  - Ultrasonically test the soot-blower heads and piping and repair or replace them as necessary.
  - Overhaul soot-blower heads in accordance with TRSs 0221-086-624 (CG-16 Copes-Vulcan), 0221-086-625 (CG-16 Diamond), 0221-086-626 (CG-26 Diamond), and 0221-086-634 (CG-26 Copes-Vulcan rotary soot blowers). There is no TRS for the Copes-Vulcan retractable soot blowers installed on CG-26 CE boilers. Set the blowing arcs and pressures and perform an operational test.

3.2.13 Boiler Water-Level Indicators

3.2.13.1 Discussion

Each B&W boiler was equipped initially with one Diamond color-port 15 1/2-inch gauge glass, supported by APLs 450010039 (right hand) and 450010040 (left hand). The FW boilers in CG-16 Class ships were originally equipped with Yarway color-port water gauges, supported by APLs 450030017 (right hand) and 450030018 (left hand). Shipalt CG-16-1088K provided for replacement of each color-port gauge glass with a Yarway 18-inch, 2,500 psi, flat boiler water gauge glass and was reported completed on all CG-16 Class ships. The CG-26 Class ships already have the Yarway flat gauge glasses, supported by APLs 450030015 and 450030016. Because the color-port gauges were replaced by the Yarway flat gauges, they will not be discussed.

The Yarway flat gauge glasses (APLs 450030034, 450030036, 450030015, and 450030016) have no significant current parts-usage data. However, discussions with ship maintenance personnel identified two noteworthy problems involving stripping of cap screw threads and cracking of spring cones.

3.2.13.2 Stripping of Cap Screw Threads

The Yarway water gauge is designed with a cap screw and spring cone assembly to hold the glass in position against the body (as illustrated in Figure 3-2). The cap screw is made with a collar that limits the cap screw's advance into the body. The correct position of the cover plate and the compression of the glass, mica, and sealing gaskets are established by the head-to-lower-collar-edge dimension of the cap screw and the curvature of the spring cones. The cap screw dimensions are carefully controlled during manufacture. The boiler technical manual specifies that during assembly of the cover plate and body, the cap screws should be taken up firmly against the body, but tightening should be stopped immediately when resistance of the cap screw collar against the body is encountered. No torque value is specified. Additional tightening will not further compress the glass, mica, and gaskets, but will overstress the cap screws and strip the threads.

One incident of stripped threads on the upper insert body and cap screw was reported on CG-16 Class ships, while 12 reports of stripped or damaged threads were reported on CG-26 Class ships. Ship maintenance personnel (CG-16 Class) reported that after receiving four new gauge glass assemblies during regular overhaul, they found several instances of "cross threading" of the cap screws. They noted the need to retap the body threads and replace the cap screws. Shipyard design personnel confirmed that thread damage is a common occurrence.

The technical manuals contain a cautionary note that standard taps and dies cannot be used to chase the gauge body or cap screw threads. A special threading set (Yarway part number 943897, size 11/16) must

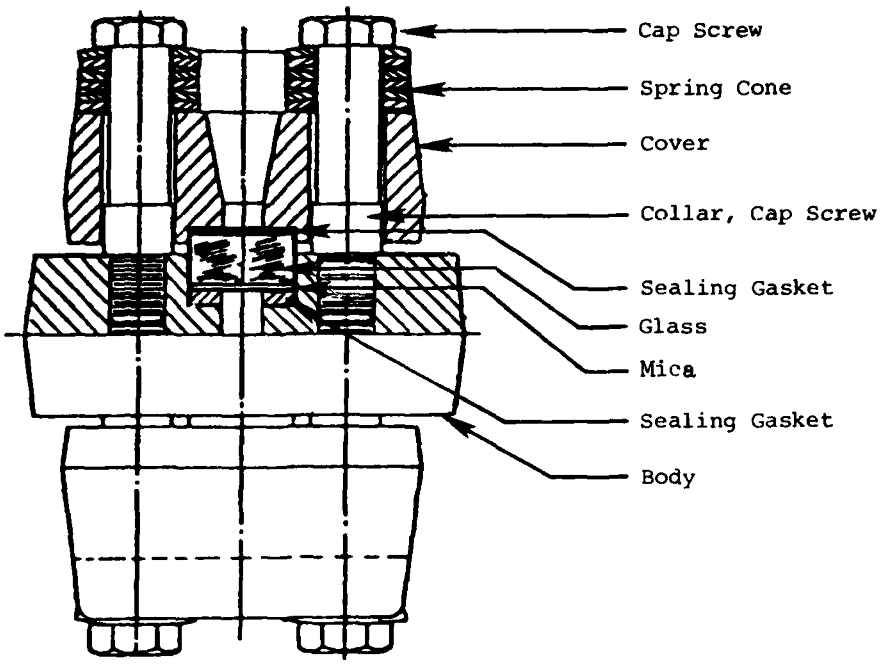

Figure 3-2. YARWAY 2,500 PSI, FLAT GLASS WATER GAUGE ASSEMBLY

be used to prevent damage. There is no apparent justification for using a nonstandard thread. To prevent the use of standard taps and dies, the Yarway gauge glasses should be marked to advise use of only the special Yarway threading set.

3.2.13.3 Cracking of Spring Cones

During a ship survey, cracked spring cones were observed. Ship maintenance personnel noted that since overhaul they had replaced 12 cap screw assemblies -- some because of cross threading, others because of cracked spring cones. Correspondence from NAVSECPHILADIV in June 1978 addressed the problem, noting that the spring cone washers are cracking because of stress corrosion resulting from a combination of high tensile stresses and the corrosive atmosphere at sea.

NAVSECPHILADIV noted a program whereby the Yarway Corporation will replace any defective cap screw assembly. Further, the manufacturer

believes that the problem has been corrected by closer monitoring of the manufacture of the spring cone washers. The washers should be inspected when the boiler water level gauges are disassembled for overhaul.

Ship operating personnel, the SURFPAC TYCOM boiler inspectors, and the DDG-37 Class main propulsion boiler ROE, recommended providing two spare gauge glass assemblies to be used as ready spares -- one in each fireroom mounted on the bulkhead. Availability of a spare gauge glass will permit immediate replacement in the event of a casualty and should reduce boiler downtime. Care should be exercised, however, in the installation of these spare gauges because shipyard personnel reported finding cracked spring cone washers on spare gauge glasses.

3.2.13.4 Boiler Water-Level Indicator Shipalts

In addition to the boiler-mounted gauge glasses, each boiler is equipped with a remote-indicating boiler water level indicator (RBWLI). Shipalts CG-16-1144K and CG-26-318K remove the originally installed RBWLIs and replace them with Barton RBWLIs. Some components of these RBWLIs are used in other applications in the automatic combustion control/feedwater control/main feed pump control system and have proven to be reliable. There is also a training and logistic support network for maintenance support of these components. Therefore, shipalts CG-16-1144K and CG-26-318K should be accomplished during BOH.

Shipalts CG-16-1093K and CG-26-241K, "Install Nucleonics RBWLIs," were developed as part of the 1200 psi steam propulsion plant improvement program to provide a third independent means of measuring boiler water level. The training and logistic support network established for maintenance of the Nucleonics RBWLIs during an extended operating cycle is not as comprehensive as that for the Barton RBWLIs. Because of the reliability record and the existing training and logistic support for the Barton RBWLIs, it is recommended that an additional Barton RBWLI be installed during BOH instead of the Nucleonics RBWLIs and that shipalts CG-16-1093K and CG-26-241K be cancelled.

3.2.13.5 ROH Repair History

Review of recent SARPs revealed that repair, calibration, and operational tests of the boiler water level indicators are normally authorized during ROHs. These actions, in addition to specific examination of cap screws, threads, and spring cone washer assemblies, are sufficient to ensure acceptable operation during an extended operating cycle and should be accomplished during BOH and ROH.

3.2.13.6 Recommendations

The following actions are recommended:

- Mark the Yarway gauge glasses to advise use of only the special Yarway threading set.

- Include tasks in the CG-16 and CG-26 Class CMPs for an IMA activity, during BOH and ROH, to examine all cap screws and body threads for damage. Replace damaged cap screws, and plug-weld and retap body threads. During BOH, ROH, or any restricted availability when the boiler water level gauges are disassembled for overhaul, have the IMA examine the spring cone washer assemblies for cracking and replace defective assemblies.
- Promulgate a specific torque value to apply to the cap screws when reassembling Yarway gauge glasses. Advise maintenance personnel to run a nut onto each cap screw all the way to the collar before reassembly to ensure that good threads are available and that no false indication of resistance will be encountered because of a damaged thread.
- Investigate the feasibility and cost-effectiveness of authorizing depot level industrial activities to disassemble the spring cone washer assemblies and replace the washers only, instead of the complete assembly.
- Add to each ship's allowance two complete gauge glass assemblies, one per fireroom, to be bulkhead-mounted.
- Accomplish at BOH shipalts CG-16-1144K and CG-26-318K, "Install Improved Remote Boiler Water Level Indicators."
- Cancel shipalts CG-16-1093K and CG-26-241K, "Install Nucleonic Water Gauges," and install instead an additional Barton RBWLI under shipalts CG-16-1144K and CG-26-318K.

3.2.14 Economizer

3.2.14.1 Discussion

The B&W, FW, and CE boiler economizers are extended surface tubes arranged in continuous loops between inlet and outlet headers. All the economizers are comparable in configuration, size, number of elements, tube size, and wall thickness. The economizer maintenance burden totaled 5,999 man-hours as reported in 80 repair actions. An average of about 75 man-hours were expended in each action, and an average of more than 60 boiler-months elapsed between those actions. There were more actions and man-hours reported, on a per-boiler-per-ship-operating-year-basis, against B&W boilers than either FW or CE boilers (see table 3-12). This difference in maintenance burden is discussed below.

3.2.14.2 B&W Economizer Tube Element Failures

The MDS data showed more economizer tube failures in B&W boilers than in FW or CE boilers. In addition, MDS records indicated procurement of economizer elements by B&W and CE ships, but not for FW ships. The B&W economizer tube elements that were reported ruptured, leaking, or plugged were not localized, but were located in the B, C, D, E, G, H,

Table 3-12. COMPARISON OF BOILER ECONOMIZER REPAIR MAINTENANCE BURDENS

Boiler	Total Actions	Actions per Boiler per Ship Operating Year**	Total Man-Hours	Man-Hours Per Boiler Per Ship Operating Year
B&W*	44	.21	3,733	17.7
FW	19	.14	1,088	8.3
CE	17	.16	1,178	10.8

*Data for CG-16 and CG-26 Class B&W boilers were summed.
**Ship operating years (SOY) represents the total ship operating time during the data period; 52.6 SOY for B&W; 27.2 SOY for CE; 32.9 SOY for FW.

R, S, T, U, and V rows. The CE economizer tube failures were also not localized. Each of the three CG-16 Class B&W ships reported element failures in the MDS and in CASREPs.

A significant dissimilarity in the designs of the FW and CE boilers and the B&W boilers may be associated with the failures; the FW boiler contains four rotating soot blowers, while the CE boiler has three rotating soot blowers installed parallel to the economizer elements. In the B&W boiler, the two economizer rotating soot blower elements are mounted perpendicular to the economizer tubes, rather than parallel (as in the FW and CE boilers). The smaller number and different orientation of the soot blowers in the B&W boilers suggest possibly less efficient removal of soot deposits in the B&W economizer than in the FW and CE economizers. The economizers on all ships are highly susceptible to moisture accumulation from the stack. If the soot remains on the economizer tubes for an extended period, the sulfur in the soot combines with moisture to form sulfuric acid, which attacks the tubes and leads to failures. To assess this condition of the economizer tubes and to determine the repairs necessary during BOH and ROH, a row of B&W boiler economizer tubes should be removed for analysis during the pre-overhaul inspection before BOH and ROH.

3.2.14.3 Recommendations

A task should be included in the CG-16 and CG-26 Class CMPs for a depot activity to remove a row of B&W boiler economizer tubes for analysis during the pre-overhaul inspection before BOH and ROH. The row to be removed should be determined by review of ship's records. If no unique history is evident, failure reports for the class indicate that rows about

one-third the distance from the left or right side (G, H, T, or U) have experienced the most failures and should be sampled. Authorization should be given for economizer repairs as found to be necessary on the basis of the analysis. FW and CE boiler economizer tubes should be removed for analysis only when shown to be necessary by the pre-overhaul inspection.

3.3 AUTOMATIC COMBUSTION CONTROL (ACC)/FEEDWATER CONTROL (FWC)/MAIN FEED PUMP CONTROL (MFPC) SYSTEMS (SWAB 221-2)

3.3.1 Background

The automatic combustion control (ACC)/feedwater control (FWC)/main feed pump control (MFPC) system contains four separate but interrelated systems, as shown in Figure 3-3. The acronym ACC/FWC/MFPC will be used throughout this report as a collective term for these four automatic systems.

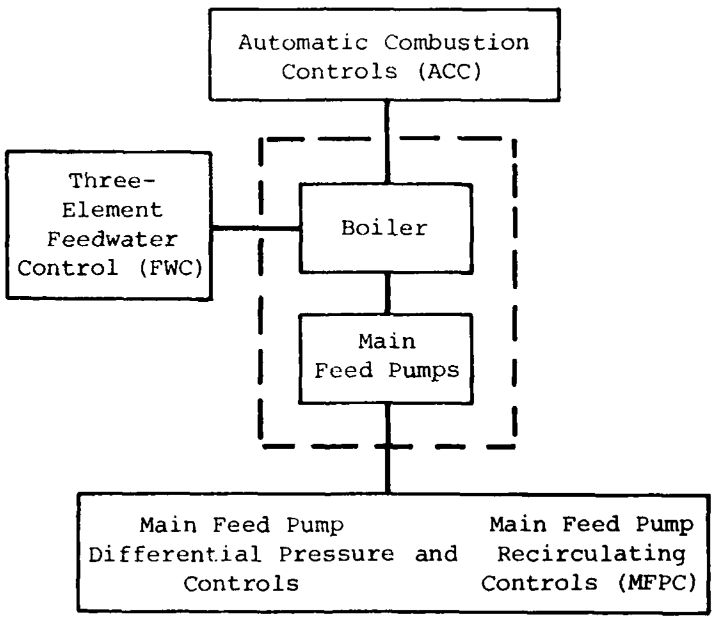

Figure 3-3. SCHEMATIC OF ACC/FWC/MFPC SYSTEM COMPONENTS

The automatic combustion controls (ACCs) monitor and control the flow of air and fuel oil to the furnace either to maintain a predetermined steam pressure (set point) for steady-state steaming or to regulate air and fuel oil flow to restore the set point after a change in steam demand has caused a steam-pressure deviation.

The three-element feedwater control system regulates the flow of feedwater to the boiler in order to maintain a predetermined level in the steam drum. Steam flow, feed flow, and drum level are measured and a control signal is generated that properly positions the final control element (the feedwater regulator valve) to maintain steam-drum water levels within the predetermined limits, regardless of steam demand.

The main feed pump differential pressure control system regulates the speed of the main feed pump turbine so that a predetermined pressure differential will be maintained across the feedwater regulator valve, thus assuring a positive feedwater flow to the steam drum as required by the steaming rate.

The main feed pump recirculating controls protect the main feed pump from overheating at low-feed-flow-demands by automatically opening a diaphragm-operated valve in a recirculation line when a predetermined minimum flow is reached. This system is not variable; it is similar in operation to an on-off switch.

Elements of reliability and maintenance affecting the performance of these systems are discussed in the following paragraphs. In addition, recommendations to improve the operation and maintenance of the systems during an extended operating cycle are also presented.

3.3.2 System Repairs

3.3.2.1 Discussion

It is evident from the MDS data that a majority (333 of 491 completed actions, or about 68 percent) of ACC/FWC/MFPC system repairs were deferred for either lack of capabilities or facilities, or because of inadequate parts support. About half (167 of 333 actions) of the deferrals submitted were attributable to a lack of capabilities or facilities. A review of CASREPs showed that ship's force often required outside assistance to troubleshoot and correct ACC/FWC/MFPC failures; this situation indicates a general lack of capabilities or facilities. These reports accounted for 14 of 36 CASREPs, or almost 40 percent of the total CASREPs submitted.

From previous experience with MDS data that relate to ACC/FWC/MFPC system maintenance, it is known that the MDS data are an incomplete representation of the ACC/FWC/MFPC systems' maintenance experience. Reported parts usage was low and no particular parts showed a high incidence of recurring failure. The reported man-hours devoted to ACC/FWC/MFPC system maintenance are also low because much of the maintenance is accomplished by outside contractors and is not reported in MDS. For these reasons, during this analysis [(as in previous ARINC Research ACC/FWC/MFPC system analyses (ARINC Research Publications 1645-03-2-1538 and 1652-03-27-1810)] heavy reliance was placed on discussions with personnel from PMS-301, the readiness support group (RSG) Norfolk, and ship visits to determine the true magnitude of historical maintenance requirements. RSGs and Maintenance Coordination Centers (MCCs) are similar organizations in SURFLANT

and SURFPAC, respectively, that serve as coordination centers for IMA level repairs. The problems discussed below are common to both organizations.

From discussions with NAVSEA PMS-301 personnel, it was learned that intermediate maintenance activities (IMAs) are less involved in repairs than is ship's force. It was also determined from discussions with RSG, Norfolk, personnel and MCC personnel in San Diego that IMA level repairs are often contracted to private companies through RSGs and the MCC; such contracting out apparently results from heavy IMA loading for repairs to other systems, and is partially attributable to a need for fast response to high-priority, short-lead-time repairs. As reported in the DDG-37 Class ACC/FWC/MFPC system maintenance analysis (SMA) (SMA 37-109-2211), fleet-wide problems exist at the RSG level that could have an adverse effect on DDEOC ship repairs if not corrected. These problems include the following:

- Ship's force do not have adequately trained personnel and procedures to handle quality assurance (QA).
- RSGs and MCCs must rely on contractor experience to obtain quality work, because specifications are not available on some work and the RSGs and MCCs do not have the capability to write specifications or perform QA tasks.
- The RSGs have no field personnel and do little job progressing, planning, and estimating. The MCC is not chartered to do that level of work.
- Contracted system repairs cannot be monitored conveniently, because contractor work is not entered into the MDS.

The solutions recommended in the DDG-37 Class SMA (SMA 37-109-2211) apply generally to all ship classes and should be implemented to remedy these problems. A detailed survey of RSGs and similar organizations should be conducted to define the problems completely and determine if the problems exist at all RSGs or other similar organizations that function as IMA coordination centers. In addition, a management system should be developed and implemented to assist RSGs and other similar organizations with the coordination of incoming work, contracts, quality assurance, and specification writing. Repairs performed by contractors should be documented in the MDS, so that the number of system repairs accomplished by outside contractors and the burden associated with those repairs can be monitored.

3.3.2.2 Recommendations

The following recommendations are made:

- Survey RSGs and other similar organizations to define the problems completely and determine if the problems exist at all IMA coordination centers.

- Develop and implement a management system to assist RSGs and other similar organizations with the coordination of incoming work, contracts, quality assurance, and specification writing.
- Document contractor-performed repairs in the MDS system.

3.3.3 Factors Affecting ACC/FWC/MFPC Calibration and Maintenance

3.3.3.1 Shipboard Facilities

Shipalts CG-16-1090D and CG-26-347D, which install pressure gauges in the signal lines, have been established to improve ship's force capabilities to troubleshoot, calibrate, and maintain the ACC/FWC/MFPC system. These shipalts have been installed on one CG-16 Class ship (CG-24) and six CG-26 Class ships (CG-28 through CG-33), and should be installed on the remainder of the ships not later than BOH to reduce ship's force and IMA dependence on contractors.

MDS data review indicated that the responsibility for ACC/FWC/MFPC maintenance is either dedicated to a unique work center (EB13) or is included with the boilers (work center EB01) or with the oil king (work center EB14). The supervisors for work centers EB01 and EB14 do not necessarily have training or experience to maintain the ACC/FWC/MFPC systems, as was discussed in the DDG-37 Class ACC/FWC/MFPC SMA (SMA 37-109-2211). This situation is also a problem in both the CG-16 and CG-26 Classes, but it is less severe because more ships of these classes have work centers dedicated to ACC/FWC/MFPC systems. The DDG-37 SMA recommended a solution to this problem that applies to the CG-16 and CG-26 Classes: establish a separate work center (EB13) to be responsible for ACC/FWC/MFPC maintenance and continue to emphasize staffing each ship with a minimum of one senior petty officer (E-5 or above), who possesses ACC/FWC/MFPC system technician qualifications and shipboard experience as the supervisor of work center EB13.

3.3.3.2 IMA Facilities

Previous SMAs for the FF-1052 and DDG-37 Classes have established that IMA calibration and repair capabilities have been limited by the availability of trained, experienced personnel. That situation has not changed with respect to the CG-16 and CG-26 Classes, as IMAs are still not staffed with adequately trained and experienced ACC/FWC/MFPC maintenance personnel. Therefore, emphasis should be placed on upgrading IMA ACC/FWC/MFPC calibration and repair capabilities, so that better support will be available to ship's force.

3.3.3.3 Training

As noted in subsection 3.3.2, there were 333 deferred maintenance actions, about half of which were attributed to a lack of capabilities or facilities. This result is not unexpected (on the basis of the results of the analyses of the FF-1052 and DDG-37 Classes' ACC/FWC/MFPC systems).

It was found during those analyses (and confirmed during this analysis) that ship's force capabilities to maintain the ACC/FWC/MFPC systems are limited by the training and experience of its crews. In addition, the current qualification procedures for ACC/FWC/MFPC system maintenance technicians hinder ship's force maintenance efforts by providing trained but inexperienced technicians to the ships. The Navy enlisted code (NEC) for system technicians is now awarded upon successful completion of the ACC/FWC/MFPC school, without providing extensive hands-on maintenance experience with the system. Sufficient training should be provided at the maintenance school to permit school graduates to adequately maintain the entire system. However, discussions with ship's force personnel have indicated that successful maintenance school completion and subsequent NEC award qualify personnel to calibrate and repair only at the component level, without providing the skills to fine tune or troubleshoot the entire system. Shipboard experience, as reported by cognizant ship's force personnel, has confirmed that personnel with only school training are not fully qualified to maintain the ACC/FWC/MFPC systems.

An expansion of the ACC/FWC/MFPC maintenance school to increase system troubleshooting training and training on fine-tuning operational systems, and to provide additional use of hot plant or school ships to complement simulator training, would improve personnel capabilities to maintain the systems.

To ensure that fully and uniformly qualified personnel will serve as primary ACC/FWC/MFPC technicians, the Navy should adopt a three-stage qualification and certification procedure for ACC/FWC/MFPC system technicians* and ensure that newly graduated students of the ACC/FWC/MFPC system school are assigned only to ships that have fully qualified, operationally experienced ACC/FWC/MFPC system maintenance technicians on board. Implementation of this recommendation will require the following three separate actions:

- Establish an ACC/FWC/MFPC system maintenance technician certification course at the system schools that will provide basic system training.
- Modify the current NEC qualification procedure by creating a new NEC (which will indicate limited qualification) for award to basic ACC/FWC/MFPC system school graduates. Reserve the existing NEC, which indicates full qualification, for award upon completion of the ACC/FWC/MFPC system maintenance technician certification course.
- Modify the current procedures for ACC/FWC/MFPC system technician assignment to accomodate the two levels of qualification defined in the first part of this recommendation.

**FF-1052 Class Automatic Combustion Control and Main Feed Pump Control System*, SMA 101A-221, ARINC Research Publication 1645-03-2-1538, October 1976.

In addition, the three-stage qualification procedure will provide the enlisted personnel distribution offices with accurate information on the level of an individual's qualification. With this knowledge, personnel may be detailed to better fulfill the needs of the fleet.

Because the findings of this analysis that relate to training are identical to those findings previously documented in the FF-1052 and DDG-37 Class SMAs, the recommendations from those analyses are applicable, therefore, to the CG-16 and CG-26 Classes and are repeated below.

3.3.3.4 Recommendations

The following recommendations are made:

- Ensure that shipalts CG-16-1090D and CG-26-347D are installed before the completion of BOH.
- Establish on all ships work center EB13 to be responsible for ACC/FWC/MFPC maintenance and continue to emphasize the staffing of each ship with a minimum of one senior petty officer (E-5 or above) who has ACC/FWC/MFPC system technician qualifications and experience as work center supervisor.
- Emphasize the upgrading of IMA ACC/FWC/MFPC calibration and repair capabilities by dedicating qualified personnel, E-5 or above with ACC/FWC/MFPC training and experience, to provide support to the fleet.
- Expand the scope of the ACC/FWC/MFPC maintenance school to provide both increased system troubleshooting training and increased training on fine-tuning operational systems. These recommendations could be accomplished by expanding the use of school ships or a hot plant to complement simulator training.
- Ensure that ships are manned with fully qualified, operationally experienced technicians by accomplishing the following actions:
  - Establish at the ACC/FWC/MFPC system schools an ACC/FWC/MFPC system maintenance technician certification course that provides basic system maintenance training.
  - Modify the current NEC qualification procedure by creating a new NEC, which would indicate a limited qualification, for award to basic ACC/FWC/MFPC system maintenance school graduates. Reserve the existing NEC, which currently indicates full qualification, for award upon completion of the ACC/FWC/MFPC system maintenance technician certification course.
  - Modify the current procedures for ACC/FWC/MFPC system technician assignment to accomodate the two levels of qualification defined in the first part of this recommendation.

3.3.4 Control Air Supply

3.3.4.1 Discussion

A major operational and maintenance-related problem affecting the ACC/FWC/MFPC systems has been oil carryover from the low pressure (LP) air compressor into the system control lines. Discussion with ship's force indicated that the oil carryover has caused sluggishness in the system and has made system calibration difficult to accomplish. A reduction in these system problems can be expected by installing shipalts CG-16-1085K or CG-26-226K, which install 100 standard cubic feet per minute "oil-free" LP air compressors and type 1 dehydrators. The "oil-free" LP air compressors and dehydrators virtually eliminate oil carryover and should eliminate problems with system sluggishness. Several CG-16 and CG-26 Class ships (CG-16 through CG-20, CG-22 through CG-24, and CG-29 through CG-34) have received installation of the shipalts; discussions with personnel assigned to some of those ships indicated that good results were obtained from the installations. On the basis of these data, it is recommended that the oil-free LP air compressor shipalts be accomplished not later than BOH. In addition, because of the oil contamination of the controls by the old compressors the control lines should be thoroughly flushed during shipalt installation to ensure that there will not be any oil remaining in the lines. Flushing will not be required at BOH for those ships which already have the oil-free compressors installed.

3.3.4.2 Recommendations

Shipalts CG-16-1085K and CG-26-226K should be accomplished before or during BOH. Control lines should be flushed thoroughly to eliminate previous oil contamination.

3.3.5 Control System Standardization

3.3.5.1 Discussion

There is an ongoing program to standardize ACC/FWC/MFPC control systems to either Hagan based or General Regulator based systems. A series of shipalts have been developed (some are already authorized while others are being processed) to standardize and update the ACC/FWC/MFPC system installations on CG-16 and CG-26 Class ships. According to NAVSEA PMS-301 personnel, a major benefit of this program will be the improvement of supply support, which has been a problem in the past because some system components were obsolete (because of a nonavailability of spare parts). Additional benefits to be expected include improved reliability and maintainability and a reduction in the number of ACC/FWC/MFPC maintenance training school curricula. Further, installing these shipalts should aid in reducing maintenance burdens during an EOC. Because of the probable benefits to system reliability and maintainability to be obtained by their installation, these shipalts should be installed not later than BOH. Table 3-13 shows the final system configurations for the CG-16 and CG-26 Class ships that will result from installation of the shipalts developed for the standardization program.

Table 3-13. SUMMARY OF ACC/FWC/MFPC SYSTEM NEW MANUFACTURER CONFIGURATION

Subsystem	Manufacturer(s)	Applicable Shipalt	Shipalt Completion Status	Hull Applicability
FWC	General Regulator	CG-16-1278K	CG-23	CG-19,20,21,22*,23
ACC/FWC	General Regulator G.W. Dahl ITT-Barton Hagan	CG-26-235K	CG-29-33 (5 of 9)	All CG-26 Class ships (Various portions of Shipalt)
FWC	ITT-Barton (General Regulator based)	CG-26-349D	CG-27,28,32 (3 of 5)	CG-26,27,28,32,34
ACC/FWC	General Regulator ITT-Barton	CG-26-500K	CG-28 & 32 (2 of 6)	CG-26,27,28,30*,32,34

*There are conflicting applicability data between SAMIS, the PERA (CRUDES)-developed shipalt information manual (SAIM) and the shipalt (NAVSEA 4720/4). SAMIS shows that these two ships are authorized to receive the respective shipalts; the other sources do not indicate applicability.

3.3.5.2 Recommendations

The following recommendations are made:

- Install shipalts CG-16-1278K, CG-26-235K, CG-26-349D, and CG-26-500K before or during BOH.

3.3.6 On-Line Verification

3.3.6.1 Discussion

On-line verification (OLV) is a program, implemented by a series of documents, to be used by ship's force in maintaining proper ACC/FWC/MFPC alignment during system operation. OLV uses the automatic/manual station pressure gauges and the pressure gauges installed in the control systems' signal lines to indicate performance. Because there are different control system and propulsion equipment configurations, a series of OLV documents has been developed by PMS-301 to detail the proper system pressures for the different configurations.

At the present time, only FF-1052 Class ships have implemented OLV. Because of configuration variations and the ACC/FWC/MFPC systems standardization (see subsection 3.3.5), none of the CG-16 and CG-26 Class ships has implemented OLV. Additional shipalts are being processed within NAVSEA to update and further standardize the control systems by installing the

newest system components available. Discussions with Navy technical personnel (NAVSEA PMS-301) indicated that the additional shipalts would probably be authorized and installed and OLV implemented during the BOHs. These actions would minimize the adverse effects caused by assigning inexperienced ACC/FWC/MFPC technicians to the ships and would improve ship's force capabilities to assess system condition and to identify the need for system maintenance.

3.3.6.2 Recommendations

OLV should be implemented by authorizing and installing the updating and standardizing shipalts currently being processed within NAVSEA PMS-301, and supplying all CG-16 and CG-26 Class ships with the OLV documents during BOH.

3.3.7 ROH Repair History

3.3.7.1 Discussion

A review of the CG-16 and CG-26 Class repair profiles and available ship alteration and repair packages (SARPs) was accomplished to determine the ROH repair history of the ACC/FWC/MFPC systems. The usual task specified for ROH was to repair and calibrate the systems (including the forced draft blower positioners) and to flush the control air lines. Class B overhauls of these systems were accomplished on two CG-16 Class ships and five CG-26 Class ships at an average of 516 man-days per overhaul. An average of 362 man-days was experienced or scheduled for repairs and calibrations of CG-16 Class systems, with an average of 247 man-days reported for CG-26 Class systems. The man-days listed for class B overhauls and the repair and calibration tasks were inconsistent, with the overhauls often requiring fewer man-days than the repairs. No satisfactory reason for this inconsistency could be determined from the data, although it may be that the man-day variations simply reflect the experience of different shipyards in planning for and estimating the costs of ACC/FWC/MFPC system work. Because the ACC/FWC/MFPC systems are critical to boiler operation and must function properly to ensure mission completion, the ACC/FWC/MFPC systems should be overhauled in accordance with the applicable technical repair standards (TRSs) at BOH and each ROH.

In addition to the system overhauls accomplished during BOH and ROH, a need for system repairs can be expected during the operating cycle. Until the shipboard capabilities to maintain the systems are established, major system repairs and system calibration should be delegated to depot facilities; with properly trained technicians however, ACC/FWC/MFPC systems should require only minimal IMA or depot assistance during the operating cycle. Any necessary repairs can be defined through the use of the boiler flexibility test specified in PMS (MRC Q-10 F-26). Therefore, the ACC/FWC/MFPC systems should be repaired and calibrated during each SRA as shown to be necessary by the results of a boiler flexibility test conducted before each SRA.

3.3.7.2 Recommendations

The following recommendations are made:

- Include tasks in the CG-16 and CG-26 CMPs for depot activities to perform the following repairs. Make the same repairs during BOH as recommended for ROH; no CMP task is required.
  - Overhaul the ACC/FWC/MFPC systems during BOH and ROH in accordance with the applicable TRS (see below) or to class B standards if a TRS is not available:

Hull	Applicable TRS
16	0221-086-623
19,20,21,22,24	0221-086-603
	0221-086-622
29,30,31,33	0221-086-630
26,27,28,32,34	0221-086-631

  - Calibrate all gauges and indicators and inspect and repair all ACC/FWC/MFPC tubing and fittings during BOH and each ROH.
  - Repair and calibrate the ACC/FWC/MFPC systems during each SRA as shown to be necessary by the results of a boiler flexibility test conducted in accordance with MRC Q-10 F-26 (MIP F-26/126-A7) prior to each SRA.

3.4 MAIN PROPULSION TURBINE SYSTEM (SWAB 231-1)

3.4.1 Background

Ships of the CG-16 and CG-26 Classes are powered by two steam propulsion plants: the forward plant (driving the starboard shaft) and the aft plant (driving the port shaft).

The propulsion turbine system consists of two double-reduction, cross-compounded turbine-gear units, with associated control systems, lubricating systems, and accessories. Each unit has a full-power-ahead rating of 42,500 shaft horsepower (300 propeller rpm) under steam conditions of 1,050 psig and 940°F total temperature at the high-pressure (HP) turbine inlet flange. The astern element (in the low-pressure (LP) turbine) is designed to furnish astern power of 6,500 shaft horsepower (160 propeller rpm) under steam conditions of 1,060 psig, 940°F total temperature at the inlet to the astern throttle valve. Each propulsion unit consists of one high-pressure and one low-pressure turbine connected (compounded) by an in-line, self-equalizing crossover pipe that has expansion joints.

All ships of both classes have functionally similar propulsion plants procured from either Allis-Chalmers, DeLaval, or General Electric. Because

of the close similarity of these ships' main propulsion turbine systems, the maintenance history and maintenance practices for all APLs of both classes will be discussed together.

3.4.2 Discussion

3.4.2.1 Maintenance History

The main propulsion turbines for ships of the CG-16 and CG-26 Classes have proven to be relatively trouble-free. There are no repair actions routinely scheduled for overhaul by depot level activities, according to the class repair profiles prepared by PERA (CRUDES). A review of six recent ship alteration and repair packages (SARPs) for ships of the CG-16 and CG-26 Classes did not reveal any major recurring deficiencies to be repaired. However, every SARP reviewed had some main propulsion turbine repairs scheduled. Typically, such class C repairs as renewing labyrinth packing, overhauling nozzle blocks, and refurbishing journal bearings were accomplished. These types of class C repairs can be expected to be required at each overhaul period.

The MDS narratives and parts summaries were studied in an attempt to detect any particularly significant recurring maintenance actions that have been historically performed by either ship's force or an IMA. None were identified. Table 3-14 compares the maintenance burdens of the HP and LP turbines by manufacturer and APL. The man-hour data were obtained from the MDS. A summary of the overall propulsion turbine maintenance burden to the ship is presented in table 3-15, which shows that maintenance burdens vary from an average of 88 hours for the Allis-Chalmers systems to 134 hours for the DeLaval systems. Even for the DeLaval turbines, the maintenance man-hour burden corresponds to an average reported monthly maintenance burden of 11 hours for ship's force and IMA personnel.

Thirty CASREPs were submitted against main propulsion turbine APLs during the 44-month period from 1 January 1975 through 31 August 1978. Of these 30, two should have been reported against main condenser APLs and eight others were readily identified as having resulted from personnel errors or the receipt of damaged parts from the supply system. The causative factors responsible for the remaining 20 CASREPs are itemized in table 3-16. Steam leaks were the most frequently occurring cause of maintenance, as about 45 percent (9 of 20 CASREPs) of the CASREPs mentioned steam leaks as the reason for the CASREP submission. Seven of these nine CASREPs were submitted for leaks at the HP turbine inlet nozzle block.

A review of parts usage (as reported in MDS) did not reveal chronically high usage of any particular parts. Journal bearings and oil deflector rings were the only parts that experienced any substantial usage. Thirty-five journal bearings were replaced in eight years for the 18 ships of both classes. Fifty-two oil deflector rings were replaced in the same time period; it appears from MDS narratives that often they were replaced only because journal bearing replacement created convenient access to them. It is significant that only six CASREPs were reported against journal bearings for the 18 ships that constituted the CG-16 and CG-26 Classes during

Table 3-14. MAIN PROPULSION TURBINE MAINTENANCE BURDEN AT ORGANIZATIONAL AND IMA LEVELS

Manufacturer	APL	Hull Number																		Total Equipment Operating Years	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours per Component per Operating Year	Average Man-Hours per Component per Operating Year
		16	17	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34					
High Pressure Turbines																								
Allis-Chalmers	051010083								X	X										10.9	362	121	44.3	33.8
	051010084								X	X										10.9	253	0	23.2	
DeLaval	051150024				X	X	X	X						X	X	X		X		49.1	1995	590	52.7	39.1
	051150026				X	X	X	X						X	X	X		X		49.1	1020	234	25.5	
General Electric	051260737	X	X	X							X	X	X				X			46.1	1291	534	39.6	32.6
	051260738	X	X	X							X	X					X		X	45.4	749	224	21.4	
	051260788																		X	6.5	357	89	68.6	
	051260792												X							7.2	57	125	25.3	
Low Pressure Turbines																								
Allis-Chalmers	051010085								X	X										10.9	197	12	19.2	9.8
	051010086								X	X										10.9	6	0	.5	
DeLaval	051150025				X	X	X	X						X	X	X		X		49.1	1660	562	45.3	28.1
	051150027				X	X	X	X						X	X	X		X		49.1	328	213	11.0	
General Electric	051260739	X	X	X							X	X	X				X		X	52.6	1163	391	29.5	28.1
	051260740	X	X	X							X	X	X				X		X	52.6	1100	307	26.8	

Table 3-15. COMPARISON OF MAINTENANCE BURDENS BY MANUFACTURER			
Manufacturer	Average Reported Man-Hours per HP Turbine Operating Year	Average Reported Man-Hours per LP Turbine Operating Year	Average Reported Man-Hours per Ship per Operating Year*
Allis-Chalmers	34	10	88
DeLaval	39	28	134
General Electric	33	28	122

*Calculated for two HP turbines plus two LP turbines.

Table 3-16. ANALYSIS OF MAIN PROPULSION TURBINE CASREP DATA BY CAUSES OF FAILURE: JANUARY 1975 THROUGH DECEMBER 1977

Category	Number of Reports			Percent of Total Reports
	CG-16	CG-26	Total	
Journal bearings	3	3	6	30
Thrust bearings	1	1	2	10
Throttle adjustments	1	1	2	10
Steam leaks	3	6	9	45
Loss of lube oil flow to bearings	0	1	1	5
	8	12	20	100.0

the period 1975 through 1977. Four of these six CASREPs were reported by ships with DeLaval turbine systems; approval has already been given to modify these ships by installing shipalts CG-16-1204 and CG-26-386 to provide more reliable pivoted-pad turbine journal bearings. The vast majority of journal bearing failures are not catastrophic; often, repair or replacement can be deferred until a shipyard or IMA availability period.

3.4.2.2 Reliability-Improvement Shipalts

There are several approved shipalts designed to improve the reliability of the CG-16 and CG-26 Class propulsion turbine systems. The previously mentioned pivoted-pad turbine journal bearing modifications for DeLaval HP and LP turbines (shipalts CG-16-1204 and CG-26-386) have been accomplished on all CG-26 Class ships and are scheduled for accomplishment on the last CG-16 Class ship (CG-22) in 1980. These shipalts should improve reliability and decrease the maintenance required on DeLaval turbine journal bearings. The remaining propulsion turbine shipalts are related to long-term improvements in reliability and do not address problems that have historically led to corrective maintenance. However, improved long-term reliability is important to DDEOC to reduce the need for future corrective maintenance. These alterations should also be accomplished either before or during BOH if funds are available. Individual reliability-improvement shipalts are discussed in subsections 3.4.2.2 through 3.4.2.4.

Shipalts CG-16-1007 and CG-26-124 were issued when, during the course of shipyard inspections of the internal parts of some DeLaval propulsion turbines, potentially hazardous conditions were discovered at the blade tenons of DeLaval HP twelfth-stage and LP second-stage blades. These alterations, developed to prevent abnormal blade failures, are classified by Naval technical personnel as moderately high priority. They are scheduled to be accomplished when those ships of the CG-16 and CG-26 Classes equipped with the DeLaval turbine undergo their next regular shipyard overhauls.

Another alteration intended to assure safe, trouble-free operation of DeLaval HP propulsion turbines in the CG-16 and CG-26 Classes modifies the eleventh stage of the high-pressure turbine to prevent abnormal blade failures caused by frequencies that result when nozzles and blades pass. These shipalts (CG-16-1328 and CG-26-501) are scheduled for accomplishment by 1982.

Shipalts CG-16-179 and CG-26-155 were issued to provide a positive means of locking the 12 cap nuts in DeLaval LP turbine astern steam rings to prevent them from loosening during normal operation. These alterations are scheduled for completion by 1982 for CG-16 Class ships and by 1980 for CG-26 Class ships.

The DeLaval HP turbine nozzle control valves will be replaced with a revised design to minimize stress concentrations and the possibility of control valve failure. These modifications are authorized by shipalts CG-16-1189 and CG-26-368. Shipalt CG-26-368 is scheduled to be completed by 1982 on all CG-26 Class DeLaval ships, but the scheduled accomplishment of shipalt CG-16-1189 does not appear in the Navy shipalt data summaries. Because potential failures of the DeLaval HP turbine nozzle control valves of CG-16 and CG-26 Classes are of equal concern, shipalts CG-16-1189 and CG-26-368 should be accomplished during BOH.

Main propulsion turbines manufactured by the Allis-Chalmers Manufacturing Company have a history of relatively trouble-free operation and,

accordingly, enjoy an excellent reputation. However, shipalt CG-16-1340 has been issued for the specific problem of erratic ahead throttle control at very low shaft rpm. Sudden unacceptable surges in propeller speed have occurred during such operation.

To correct the rotational speed surge problem, this shipalt provides for the installation of a second coil spring within an existing turbine throttle valve spring. The resultant resistive force of the two springs is sufficient to overcome the steam chest pressure acting against the valve lifting rods. This improves throttle control at low speeds. Shipalt CG-16-1340 is scheduled for accomplishment in 1982 for CG-23 and 1983 for CG-24.

All of the shipalts described in this section are scheduled for completion either before or during each ship's BOH (with the possible exception of shipalt 1189). These shipalts should be accomplished to ensure reliability and, in the case of the pivoted-pad journal bearings for the DeLaval turbines, to decrease the maintenance burden during the extended operating cycle.

3.4.2.3 PMS Requirements

The planned maintenance system (PMS) requirements for ships of the CG-16 and CG-26 Classes are considered adequate for maintaining the propulsion turbine system throughout an extended operating cycle. Neither additional requirements nor reductions in existing requirements are considered necessary. The only scheduled PMS action that requires outside assistance is bench testing of the propulsion turbine sentinel pressure-relief valves. This item is performed once each cycle and requires IMA or depot level support.

The reviews of overhaul work packages, shipyard departure reports, CASREP data, MDS narratives and parts information, pending shipalts, and PMS requirements verify that main propulsion turbines will operate without major planned restorative maintenance throughout an extended operating cycle. The existing maintenance requirements are considered adequate for use in an extended operating cycle.

3.4.2.4 Baseline Overhaul Requirements

The baseline overhaul in the DDEOC Program is designed to provide the maintenance necessary to restore a ship to a condition in which, with a well engineered and executed maintenance program, it can be expected to perform satisfactorily over an extended operating cycle.

The PERA (CRUDES) POT&I plan (which utilizes the 1200 psi steam propulsion plant shipboard test procedure no. 231F800030) sets forth pre-overhaul inspections for the main propulsion turbines. Deficiencies noted during POT&I and from the ship's CSMP should be corrected during BOH. Applicable shipalts addressed in subsection 3.4.2.1 should be completed

because they were designed to improve the reliability of the propulsion turbine systems and to help ensure satisfactory operation of the main propulsion turbines through an extended operating cycle.

3.4.2.5 Intracycle Maintenance Requirements

Analysis of the propulsion turbine system has shown these turbines to be reliable. There is no evidence that they have been the source of a major maintenance burden. However, some maintenance will be required, as is evidenced by the MDS historical data. It is concluded that all normally recurring intracycle maintenance requirements are adequately addressed by current PMS procedures. Significant casualties to individual turbines are rare and cannot be predicted. They should be addressed as they occur, on a case-by-case basis.

3.4.2.6 Follow-On ROH Requirements

On the basis of this analysis and impending reliability-improvement shipalts, major repairs are not expected to be necessary at regular overhaul periods. Some maintenance may be required, but repairs during regular overhaul periods should be based on ships' CSMPs and the results of POT&I reports.

3.4.3 Recommendations

As a result of this analysis, the following recommendations are made:

- During baseline overhaul
  - Accomplish depot level class C repairs as indicated to be necessary by ships' CSMPs and POT&I reports. Repair actions that may be expected include renewal of gland packing, repair of throttle valves, and adjustment of throttle linkages.
  - Reduce maintenance of the journal bearings on DeLaval turbines by accomplishing shipalt CG-16-1204 on the CG-22. This shipalt has been reported complete on all other applicable ships.
  - Improve the overall reliability of the main propulsion turbines by accomplishing the following shipalts (if not previously completed):

CG-16-1007	CG-16-1340
CG-16-1328	CG-26-124
CG-16-179	CG-26-501
CG-16-1189	CG-26-155

- Perform PMS actions as scheduled during the extended operating cycle. Outside assistance for corrective maintenance is not expected to be necessary.

- During regular overhaul
  - .. Include a qualified task in the CMP for depot level class C repairs to the HP and LP turbines, labyrinth packing, nozzle blocks, and journal bearings, as shown to be necessary by POT&I and each ship's CSMP.
  - .. Include an engineered task in the CMP for IMA or depot level bench testing of propulsion turbine sentinel pressure-relief valves.

3.5 PROPULSION SHAFTING (SWAB 243-1)

3.5.1 Background

The propulsion shafting system transmits rotary power from the two main propulsion engines to the propellers. The shafting (identical on all ships of both the CG-16 and CG-26 Classes) is fitted with thrust bearings, in-board line shaft spring bearings, stern tube seals, and stern tube and strut bearings. This system was selected for analysis on the basis of its average industrial maintenance burden during shipyard overhaul periods. The only individual components for which sufficient MDS data had been reported to warrant analysis were the line shaft bearings and the shaft seals. Table 3-17 presents a summary of the corrective maintenance burdens for these components.

3.5.2 Discussion

3.5.2.1 Line-Shaft Bearings

The in-board propulsion shafting of each CG-16 and CG-26 Class ship is supported by six steady (spring) bearings, which are identified as line shaft bearing assemblies (APLs 371010128 and 371010129) in table 3-17. These antifriction, metal lined, horizontally split, ring oiled bearings are spherically seated in bearing pedestals. Lubrication is provided by shaft rotated oiler rings that carry oil from the oil sump in the pedestal up onto the shaft journal. These oiler rings hang loosely on the top of the shaft journal and are kept in proper longitudinal position on the shaft by fixed oil ring guides attached to the upper half of the spring bearing. Access covers are provided over these guides for inspection of the journals and oiler rings.

Analysis of CG-16 and CG-26 Class MDS data revealed that each line shaft bearing has required an average of six man-hours of maintenance per operating year. Failure modes identified from MDS and CASREP narratives consisted primarily of wiped bearings, babbit separation from the bearing shell, and oil rings reported as having been broken during maintenance. A total of eight CASREPs were submitted for CG-16 and CG-26 Class line shaft bearings during the period 1 January 1972 through 31 August 1978. This period encompasses approximately 104 total ship operating years, resulting in an average of one CASREP every 12 bearing-years. Of the eight

Table 3-17. MAINTENANCE BURDEN SUMMARY FOR CG-16 AND CG-26 CLASS PROPULSION SHAFTING SYSTEM

APL	Nomenclature	Applicable Ships	Components per Ship	Total Component Population	Ship Operating Years	Component Operating Years	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Equipment per Operating Year
371010128 371010129	Line Shaft Bearing Assemblies	18	6	108	112.8	676.8	3,388	663	4,051	6.0
831000034	Propulsion Shaft Seal	18	2	36	112.8	225.6	1,635	1,500	3,135	13.9

reported CASREPs, two reported flooding, four reported wiped bearings, one reported a broken oil ring, and one reported babbit separating from the bearing shell. As a result of reviewing both the MDS and CASREP narratives, there is no evidence to indicate any class-wide problems associated with line shaft bearings.

MDS reported parts usage was reviewed, but no significant parts usage was evident. This finding is consistent with what would normally be expected, because wiped bearings and babbit separations from the shell normally lead to bearing repairs (rather than replacement), and broken oil rings are replaced with rings manufactured by an IMA or depot facility.

The existing PMS requirements consist of cleaning the lube oil sump and renewing the lube oil semiannually, and inspecting the line shaft bearing once each cycle (or whenever needed). PMS requirement R-6 of MIP E-12/139-B7 further requires that bearing reaction tests be performed on line shaft bearings following each regular availability drydocking. This test requires outside assistance from a repair facility and should be included as an engineered task in the class maintenance plan for accomplishment during each ROH. This task is also required during baseline overhaul. On the basis of the low corrective maintenance historically required by these bearings during the operating cycle, the existing PMS requirements are judged to be adequate.

3.5.2.2 Shaft Seal Assembly

The shaft seal assembly is comprised of two separate seals - a prime seal and a spare seal - arranged in tandem. The forward seal is the prime sealing unit and the aft seal is the spare unit. When it is necessary to repair or replace the prime sealing elements (the forward seal) with the ship waterborne, the aft seal (which is inflatable) is used to seal the shaft. The shaft seals are water-lubricated during operation by means of the stern tube cooling water system.

MDS parts usage data reveal that 18 face type seals (NIIN 713-3598) and six inflatable seals (NIIN CC4-7671) were replaced on 11 CG-16 Class ships and three CG-26 Class ships during the MDS data period. There were eight CASREPs submitted on the shaft seals during the CASREP data period. Five of these CASREPs reported excessive leakage, two reported ruptured inflatable seals, and one reported the syntron seal as "carried away". The severity code of eight CASREPs was C-2, which indicated only minor degradation of mission capability. The low repair-parts usage, coupled with the infrequent CASREPs, indicate that the shaft seals have been generally reliable on the CG-16 and CG-26 Classes and have not contributed significantly to the overall maintenance burden. This indication is supported by the reported maintenance burden of 13.9 man-hours per component per operating year, as shown in table 3-17. PMS requirement R-5 of MIP E-12/137-B7 calls for shaft seals, face seals, and garter springs to be routinely renewed at each drydocking. Accordingly, seal renewal should be scheduled for accomplishment at BOH and ROH. NAVSEC technical personnel assert that the seals should provide satisfactory service for at least five years if they

are installed properly and are not abused during use. Such abuse will not occur if the existing PMS requirements are performed conscientiously during the operating cycle. Included are the requirements to test the inflatable shaft seal semiannually, reposition the face seals when gland leak-off becomes excessive, and renew the bulkhead packing as indicated to be necessary by a compartment air test. These requirements are considered to be adequate on the basis of the low historical maintenance burden of this system during the operating cycle.

Shipalts CG-16-1373D and CG-26-0544D are authorized and will replace the existing concentric shaft seal with an eccentric seal --- one whose face is slightly eccentric with the shaft and will give the seal a positive radial motion relative to the gland face. The radial motion will also help to lubricate the seal by "pumping" more water between the seal and the gland and prevent face seal grooving. The installation of these shipalts is currently being scheduled by PERA (CRUDES).

Several PMS required inspections must be performed when the ship is drydocked to ensure protection against flooding. These inspections are covered by MIP E-12/139-B7, MRC R-4, which requires the drydocking activity to measure stern tube and strut bearing clearances and to inspect the condition of shaft coverings. These inspections should be performed at BOH and each ROH.

3.5.3 Recommendations

The following maintenance actions should be included in the DDEOC Program:

- BOH Requirements
    - Perform bearing reaction tests on line shaft spring bearings. This task should be assigned for depot level accomplishment in accordance with MIP E-12/139-B7, MRC R-6 and should be included in the DDEOC repair requirements for BOH.
    - Renew inflatable shaft seals, face seals, and garter springs. This task should be accomplished by the depot level activity in accordance with MIP E-12/139-B7, MRC R-5 and should be included in the DDEOC repair requirements for BOH.
    - Measure stern tube and strut bearing clearances and inspect condition of shaft coverings. This task should be accomplished at the depot level in accordance with MIP E-12/139-B7, MRC R-4 and should be included in the DDEOC repair requirements for BOH.
- ROH Requirements
    - Include an engineered task in the CMPs for depot level accomplishment of bearing reaction tests on line shaft spring bearings in accordance with MIP E-12/139-B7, MRC R-6.

- .. Include an engineered task in the CMPs for depot level renewal of inflatable shaft seals, face seals, and garter springs in accordance with MIP E-12/139-B7, MRC R-5.
- .. Include a depot level engineered task in the CMPs for measurement of stern tube and strut bearing clearances and inspection of the condition of shaft coverings in accordance with MIP E-12/139-B7, MRC R-4.

3.6 COMBUSTION AIR SYSTEM (FORCED DRAFT BLOWERS) (SWAB 251-1)

The combustion air system consists of eight steam-turbine-driven forced draft blowers (FDBs), four motor-driven lighting-off blowers, support equipment, and associated ducting. There are four FDBs and two lighting-off blowers in each of two firerooms; two FDBs and one lighting-off blower supply each boiler. The lighting-off blowers provide combustion air to the burners during initial boiler light-off until sufficient steam pressure is raised to operate the FDBs. The FDBs then provide combustion air to the boilers during normal steaming operations, from auxiliary steaming through full-power operation.

A study of the total class maintenance burden revealed that of the combustion air system components, only the forced draft blowers had a significant maintenance burden contribution. This was true for both the CG-16 and CG-26 Classes; therefore, only the forced draft blowers were chosen for maintenance analysis.

3.6.1 Background

All ships of both classes have functionally similar FDBs; all are vertically mounted, turbine-driven, two-stage axial-flow compressors with similar performance ratings. In fact, with the exception of the Hardie-Tynes blowers on the CG-24, all FDBs were procured from the Carrier Air Conditioning Company. A breakdown of the distribution of the installed equipment by APL and hull number is presented in table 3-18. Because of the similarity of all FDBs in the CG-16 and CG-26 Classes, maintenance practices for both classes will be discussed together.

3.6.2 Discussion

All of the forced draft blowers addressed in this report are functionally similar, if not identical, to the DDG-37 Class equipment studied reported in ARINC Research Publication 1652-03-13-1739 of April 1978, *System Maintenance Analysis, DDG-37 Class Combustion Air System.*

The maintenance burdens of the CG-16 and CG-26 Class FDBs are compared with those of the DDG-37 Class by APL in table 3-19. The CG-16 and CG-26 Class FDBs had histories similar to those of the DDG-37 Class blowers, but in every case the CG-16 and CG-26 Class blowers required less maintenance than their DDG-37 Class counterparts, when compared by manufacturer.

Table 3-18. FORCED DRAFT BLOWER CHARACTERISTICS FOR CG-16 AND CG-26 CLASSES

Hull Number	Component Identification (CID)	Manufacturer	Number of Component Stages	Rated Capacity (cfm)	Rated Maximum Speed (rpm)	Type	Mounting	Designed Power Rating, Full Power (bhp)
24	057960009	Hardie-Tynes Manufacturing Company	2	35,000	5650	Vane Axial	Vertical	790
23	057990007	Carrier Air Conditioning Company	2	26,000	5000	Vane Axial	Vertical	840
16,17, 18,19, 20,21, 22	057990008	Carrier Air Conditioning Company	2	37,800	7950	Vane Axial	Vertical	1023
26 thru 34	057990010	Carrier Air Conditioning Company	2	37,800	7900	Vane Axial	Vertical	986

Table 3-19. CORRECTIVE MAINTENANCE BURDEN SUMMARY FOR THE FORCED DRAFT BLOWERS

Ship Class	Manufacturer	APL	Applicable Ships	Total Component Population	Ship Operating Years	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Component per Operating Year
CG-16	Hardie-Tynes Manufacturing Company	057960009	1	8	6.1	1,424	87	1,511	31
	Carrier Air Conditioning Company	057990008	7	56	41.5	3,486	2,485	5,971	18
	Carrier Air Conditioning Company	057990007	1	8	4.8	214	184	398	10
CG-26	Carrier Air Conditioning Company	057990010	9	72	60.4	5,031	1,530	6,561	14
DDG-37	Carrier Air Conditioning Company	057990003	2	16	11.6	994	776	1,770	19
	Hardie-Tynes Manufacturing Company	057960005/26	5	40	25.4	8,042	2,893	10,935	54
	Hardie-Tynes Manufacturing Company	057960009	1	8	5.1	2,296	768	3,064	75

A maintenance history profile was prepared for each of the 144 FDBs in the CG-16 and CG-26 Class ships to identify any trends in recurring maintenance required as a function of elapsed time after overhaul. No trends were discernible; FDB malfunctions appeared to occur randomly. Many blowers provided relatively trouble-free service for the entire eight years of the data period, while others experienced numerous component failures requiring outside repair assistance. The overwhelming majority of the maintenance actions involved such peripheral components as leaking packing, steam cut valves, throttle and governor problems, and tachometer problems. A review of the MDS parts-usage summary showed that bearings were the only FDB parts that had significant usage. Journal bearings were replaced 37 times and thrust bearings shoes were renewed 32 times during the 112.8 ship operating years (SOY) reviewed. Only rarely could failures be identified that required repairs to the turbine blading or casing or blower internals. These findings agree closely with the failure modes identified for the DDG-37 Class forced draft blowers. A comparison of significant parts is shown in table 3-20.

The MDS data show that the DDG-37 Class Carrier journal bearings experienced a slightly longer average time between replacement than the CG-16 and CG-26 Class bearings. Conversely, the DDG-37 Class Carrier thrust bearing shoes had a shorter average time between replacements than the CG-16 and CG-26 Class thrust bearing shoes. The DDG-37 Class Hardie-Tynes sleeve bearings and thrust bearing shoes had longer average times between replacements than the CG-16 Class parts, apparently indicating better reliability. However, both the Carrier and Hardie-Tynes parts comparisons rely in part on limited sample sizes, which could result in parts-usage data that differs greatly from the norm. Although the MDS data were thoroughly reviewed and discussions were held with Navy technical personnel about these forced draft blowers, no other cause for these differences in usage of apparently identical parts could be identified. Because of the redundant installations of forced draft blowers, a limited number of part failures and replacements can be tolerated without seriously degrading ships' missions. These parts can therefore continue to be maintained on a run-to-failure basis, recognizing that these parts can be replaced by ship's forces.

Thirty-one forced draft blower casualty reports (CASREPs) were submitted by the CG-16 and CG-26 Class ships during the period 1 January 1975 through 31 August 1978. Analysis of these CASREPs showed that no two casualties were the same. Most of the failures, like the DDG-37 Class CASREPs, were related to lube oil problems, steam valve problems, or leaking packing (steam or oil seals) that had become intolerable. When the numbers of CASREPs submitted against the Carrier and Hardie-Tynes blowers were compared, it was found that the Hardie-Tynes blowers had experienced approximately twice the average time between CASREP submissions as the Carrier blowers. The Hardie-Tynes blowers had a CASREP submitted approximately every 2.7 ship years, while the Carrier blowers had one submitted every 1.6 ship years. Thus, the CG-16 and CG-26 Class Carrier blowers are more likely to experience mission-degrading failures than the CG-16 Class Hardie-Tynes blowers. The reverse is true for DDG-37 Class Carrier and Hardie-Tynes blowers.

Table 3-20. REPETITIVE FORCED DRAFT BLOWER PARTS USAGE

Class	Applicable Ships	NIIN	Nomenclature	Quantity per Component	Ship Operating Years	Quantity Replaced	Average Ship Operating Years Between Replacements
Carrier Forced Draft Blowers							
DDG-37	2	620-7420	Journal bearing	2	11.6	3	3.9
	2	620-7409	Thrust bearing shoe*	12	11.6	71(6)	1.9
CG-16	8	620-7420	Journal bearing	2	46.3	14	3.3
	8	620-7409	Thrust bearing shoe*	12	46.3	48(4)	11.6
CG-26	9	620-7420	Journal bearing	2	60.4	19	3.2
	9	620-7409	Thrust bearing shoe*	12	60.4	253(21)	2.9
Hardie-Tynes Forced Draft Blowers							
DDG-37	6	317-4325	Sleeve bearing	2	32.4	10	3.2
	6	036-3082	Thrust bearing shoe*	8	32.4	80(10)	3.2
CG-16	1	317-4325	Sleeve bearing	2	6.1	4	1.5
	1	036-3082	Thrust bearing shoe*	8	6.1	0(0)	--

*Usually replaced in sets.

3.6.2.1 General Problems Affecting Vertical FDBs

The following paragraphs describe a general problem encountered by all vertically mounted FDBs of the CG-16, CG-26, and DDG-37 Class ships. This deficiency was identified during discussions with NAVSEC technical codes and visits to ships of all three classes.

Water in the Lube Oil

Most CG-16 and CG-26 Class ships have been troubled by water in the lube oil. This problem is similar to one previously identified in the DDG-37 Class vertical FDBs. There are several sources of this water: (1) gradual deterioration of the turbine labyrinth seals, (2) leaking of exhaust and relief valves, and (3) condensation in the lube oil sump when the blower and gland exhauster are secured. Because ship's force personnel have learned to compensate for water in the lube oil by draining the water before lighting off, purifying the oil and changing it frequently, and checking the oil every four hours while the blower is running, water has not been the cause of significant maintenance (such as wiped bearings) as would normally be expected. However, there is a potential for major casualties if preventive maintenance procedures are relaxed or neglected. A ship visit to the USS DALE, CG-19, revealed that this particular ship had not been experiencing problems with water in the lube oil, but the crew felt that their situation was unusual and that most ships of the class did have the problem.

One of the major problems contributing to water in the lube oil is that lower turbine labyrinth seals are difficult for ship's force to replace; consequently, a leaking seal is often tolerated. As in the DDG-37 Class FDB analysis, it is anticipated that some of these seals will require replacement during the selected restricted availability (SRA) periods between regular overhauls (ROH).

Another point of entry of water into the lube oil concerns the FDB exhaust and relief valves. Ship's force personnel estimated that these valves begin to leak and require dressing up of the seats and discs every 18 to 24 months. These 8-inch valves are large and heavy and cannot be easily removed by ship's force to send to an IMA for testing and repairs. Because of this difficulty in removing the valves and replacing them it is sometimes easier to accept the possibility of water entering the lube oil if the valves leak than to remove and reinstall the valves. It appears that these valves should be assigned to ship's force for periodic dressing of the valve seats and discs to prevent steam leakage into the turbine. It is recommended that an MRC be developed to dress the seats and discs of the exhaust and relief valves every 18 months. This recommendation is identical to that made for the DDG-37 Class FDB exhaust and relief valves. It should be noted that the crew of the USS DALE consider repair of the exhaust and relief valves a standard item and that they budget time for these refurbishments to be performed once a year. The USS DALE's preventive refurbishment frequency rate seems somewhat extreme, but they have had excellent performance from their FDBs.

Another proposed solution to the problem of water in the lube oil (previously documented in the DDG-37 Class FDB SMA), is to keep the gland exhaust system lined up and the gland exhaust fan running at all times. This change in securing procedure for FDBs and other turbine-driven equipments has three potential benefits:

- It can remove the moisture, resulting from the gland seal steam's condensing in the turbine casing, that may be entering the lube oil sump.
- It can prevent rust formation in the turbine casing by removing moisture.
- It can lessen moisture collection in the gland exhaust fan motor windings and bearings, thus decreasing the frequency of bearing replacements and motor rewindings.

Recommendations

The following recommendations are applicable to all vertically mounted FDBs without regard to the ship class on which they are installed:

- Change the engineering operational sequencing system (EOSS) securing procedures to permit the FDB turbine casing low-pressure drain or blow-down lines to remain open at all times while the turbine is secured.
- Change the EOSS securing procedures to allow the gland seal steam exhaust line to remain open while the turbine is secured and the gland seal condenser exhaust fan to run continuously regardless of the plant's steaming condition.
- Develop a maintenance requirement for ship's force to dress the seats and discs of the exhaust and relief valves every 18 to 24 months.
- Develop a qualified CMP task for IMA accomplishment, with ship's force assistance, to perform class C repairs to forced draft blower components at 20-month intervals. Anticipated repairs will include replacement of labyrinth packing, refurbishment of steam valves, and overhaul of governors.

3.6.2.2 Maintenance Profiles of Particular FDBs

The following paragraphs address those maintenance histories uniquely associated with FDBs installed on CG-16 and CG-26 Class ships.

Hardie-Tynes Blowers, APL 057960009

Only the CG-24 has Hardie-Tynes blowers, and their maintenance burden was considerably smaller than the maintenance burdens reported for the Hardie-Tynes blowers of the DDG-37 Class. The CG-24 FDBs did require more maintenance than any of the Carrier blowers -- probably because of the

complexity of the Hardie-Tynes design as compared with the simpler, more modern Carrier designs. Even so, the Hardie-Tynes forced draft blowers have been reliable and capable of performing through a 60-month operating cycle without an overhaul and with only minor depot level assistance required. In fact, no evidence was found that would support routine class B overhauls of the Hardie-Tynes FDBs during BOH or succeeding overhauls. Rather, overhauls should be based on the results of POT&I, vibration analysis, and bearing and rotor alignment and clearance checks. It is anticipated that considerable class C repairs will be required for such specific components as steam valves, bearings, and packing, and that the correct decision may be to repair some of the FDBs through a class B overhaul. But class B overhauls should not be routinely scheduled; risks of failure are not so large that the loss of a FDB due to failure to class B overhaul will jeopardize the ship's operational readiness.

Carrier Blowers, APLs 057990007, 057990008, 057990010

The Carrier forced draft blowers should provide reliable service through a 60-month operating cycle. In fact, as partial evidence of that ability, the CG-27 blowers (APL 0579900010) operated for 67 months between 1972 and 1978 without requiring any outside assistance for corrective maintenance. As with the Hardie-Tynes blowers, it is recommended that Carrier blowers be overhauled only when indicated necessary by POT&I. Except for an overhaul requirement based on the above tests, these blowers should receive class C repairs only on components identified by either the above tests or by the ship's force deferred maintenance list. These recommendations are applicable to the BOH and succeeding ROHs.

Recommendations

The maintenance policy recommended for the forced draft blowers of the CG-16 and CG-26 Class ships is to perform class B overhauls only when dictated by the results of POT&I, vibration analysis, or bearing and rotor clearances and alignment checks. In all other cases, only class C repairs should be made as failures of FDB components are detected.

Recommendations regarding specific requirements include the following:

- Baseline Overhaul Requirements. Only class C maintenance of an unspecified nature is anticipated for most FDBs of the CG-16 and CG-26 Classes. However, some class B overhauls may be required to bring forced draft blowers into specified clearance tolerances. Specific details of work to be scheduled for each ship must be developed by careful inspections made shortly before the overhaul period. It is anticipated that approximately three of the eight FDBs per ship may require class B overhauls to restore them to an acceptable operating condition.
- Intracycle Maintenance Requirements. A qualified task should be included in the CMP for ship's force and IMA to perform class C repairs identified by the CSMP to be accomplished every 20

months. In addition, an engineered task should be included for ship's force or IMA to dress seats and discs of exhaust and relief valves every 18 months.

- Follow-On ROH Requirements. A qualified task should be included in the CMP for depot level accomplishment of class C repairs to forced draft blowers as shown to be necessary by POT&I and CSMP, Anticipate that complete overhauls of three of the eight FDBs installed on each ship would be required. The repair profile for the CG-16 Class ships should be revised to reflect this maintenance strategy for the forced draft blowers. The proposed CG-26 Class repair profile is already in agreement with the basic recommendation of this SMA.

- EOSS. The Engineering Operational Sequencing System should be modified to reduce the likelihood of water contamination of the lube oil. The required changes should allow the FDB turbine casing low-pressure drain or blow-down lines to remain open at all times when the turbine is secured. The gland seal steam exhaust line should remain open to the turbine, and the gland seal condenser exhaust fan should be run continuously, regardless of the plant's steaming condition.

- PMS Changes. A PMS requirement should be developed to have ship's force dress the seats and discs of the exhaust and relief valves every 18 to 24 months.

3.7 CONDENSERS AND AIR EJECTORS (SWABs 254-1, -2, and -3)

The condensers and air ejectors system consists of the main and auxiliary condensers and air ejectors, auxiliary gland exhaust condensers, and gland exhausters. The condensers and air ejectors of the CG-16 and CG-26 Classes are functionally and schematically identical and will be discussed together. Table 3-21 presents the APL configuration with the reported organization and IMA maintenance burdens. The gland exhaust fan motor APLs could not be completely correlated to their associated fan APLs with the available information. However, the reported gland exhaust fan motor maintenance was generally minimal and was not considered worthy of a separate detailed maintenance analysis.

3.7.1 Main Condensers and Main Air Ejectors

3.7.1.1 Background

Steam from the main propulsion turbines is exhausted to the main condensers, where the latent heat of vaporization is removed by the main saltwater circulating system cooling water (which flows through more than 5,000 condenser tubes). The steam is condensed and recovered in the hotwell section of the main condenser, then pumped by the main condensate pumps through the main air ejector condenser to the boiler feedwater system. Air and other noncondensable gases that enter the main condenser with the exhaust steam are drawn off by the main air ejector through an opening in

Table 3-21. MAINTENANCE BURDEN SUMMARY FOR CONDENSERS AND EJECTORS

Nomenclature	APL	Applicable Ships	Ship Operating Year	Number of Components	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Component per Operating Year for an APL	Average Man-Hours per Component per Operating Year
Main Condensers	040800074	16,17,18	19.4	3	324	437	761	39.2	24
	040800075	16,17,18	19.4	3	28	16	44	2.3	
	040800046	19,20,21,22	21.9	4	234	55	289	13.2	
	040800047	19,20,21,22	21.9	4	301	19	320	14.6	
	040100021	23,24	10.9	2	265	95	360	33.0	
	040100022	23,24	10.9	2	6	20	26	2.4	
	040800102	26,27,28,32,34	33.2	5	856	281	1137	34.2	
	040800103	26,27,28,32,34	33.2	5	764	408	1172	35.3	
	040900033	29,30,31,33	27.2	4	538	530	1068	39.3	
	040900034	29,30,31,33	27.2	4	191	32	223	9.2	
Auxiliary Condensers	040040011	16,19,20,23	21.1	16	61	24	85	1.0	3.5
	040090111	17,18,21,22,24	31.3	20	264	0	264	2.1	
	040800098	26,27,28,32,34	33.2	20	638	177	815	6.1	
	040900037	29,30,31,33	27.2	16	340	80	420	3.9	
Auxiliary Gland Exhaust Condensers	040400066	19,20,21,22	21.9	8	224	560	784	17.9	12.8
	040110003	16,17,18	19.4	6	379	15	394	10.2	
	040960007	23,24	10.9	4	221	16	237	1.7	
	040010020	29,30,31,33	27.2	8	491	53	544	10.0	
	040110003	26,27,28,32,34	33.2	10	326	604	930	14.0	
Gland Exhaust Fans	400020120	16 through 24	52.4	18	56	145	201	1.9	1.1
	400020186	26,27,28,32,34	33.2	10	30	0	30	.5	
	400120019	29,30,31,33	27.2	8	10.2	0	10	.2	
Auxiliary Gland Exhaust Fans	400020121	16 through 24	52.4	18	161	22	183	1.7	.8
	400020185	26,27,28,32,34	33.2	10	0	0	0	0	
	400120020	29,30,31,33	27.2	8	2	0	2	0	
Auxiliary Condenser Gland Exhaust Fans	400120007	16,17,18,21,22,23,24	42.7	14	142	202	344	4.0	2.9
	400120015	19,20	9.7	4	83	72	155	8.0	
	400120017	26,27,28,32,34	33.2	10	17	104	121	1.8	
	400120021	29,30,31,33	27.2	8	26	0	26	.5	
Gland Exhaust Fan Motors	174802060	16,17,18,23,24	30.5	10	163	500	663	10.9	5.0
	174801968	19,20,21,22	21.9	8	48	41	89	2.0	
	174750770	16 through 24	52.4	18	600	594	1194	11.4	
	174751313	29,30,31,33	27.2	8	24	0	24	.2	
	174802426	26,27,28,32,34	33.2	10	57	99	156	2.3	
	174802427	26,27,28,32,34	33.2	10	58	54	112	1.7	

the condenser shell located above the condensate level. The main air ejectors are two-stage units that are driven by 150 psi nondesuperheated auxiliary steam. The first stage air ejector exhausts to an interstage condenser; the second stage air ejector takes suction on the interstage condenser and exhausts to an after condenser. The after condenser contains a segregated section that serves as a gland exhaust condenser for steam and noncondensable gases entrained in the main turbine gland exhaust system. A gland exhaust fan removes air from the gland exhaust condenser portion of the air ejector condenser and exhausts it to atmosphere.

3.7.1.2 Discussion

The main condensers and air ejectors on the ships of the CG-16 and CG-26 Classses have been relatively trouble free. The average maintenance burden of all the main condensers reported in table 3-21 is 24 man-hours per component per operating year. However, a review of MDS narratives revealed that approximately 30 percent of the reported man-hours actually occurred during accomplishment of deferred PMS actions or during IMA accomplishment of PMS actions requested through the MDS system, rather than occurred as a result of corrective maintenance. A study of parts usage did not reveal repetitive usage of any significant parts. Also, maintenance actions other than those prescribed by the PMS appeared to be random in nature -- no trends were discernible. The gland exhaust fans (APLs 400030130, 400020186, and 400120018) associated with the main air ejectors required a negligible average of only one maintenance man-hour per component per operating year. This small burden is not sufficient to warrant detailed analysis. A run-to-failure maintenance strategy is recommended for the gland exhaust fans.

A main condenser failure can quickly lead to massive chloride contamination of the condensate, feedwater, and boiler systems. Because proper operation of the main condensers is so critical, it is reasonable to anticipate that most condenser failures will result in the issuance of a CASREP. During the period 1 January 1972 through 31 August 1978, a total of eight CASREPs were issued on the main condensers and main air ejectors of the combined ships of the CG-16 and CG-26 Classes. Four of the eight CASREPs dealt with cracks or corrosion in the hotwell and three CASREPs reported leaking condenser tubes. The other CASREP reported an unexplained failure of a main air ejector. This CASREP rate of eight reported casualties during approximately 183 component operating years (.04 CASREPs per component per operating year) is considered minor.

The PMS requirements for the main condensers entail significant man-hour expenditures on the part of ship's force and IMA personnel; such man-hour expenditures are the primary reason why these equipments were selected for analysis. Although the PMS burden is major, all required maintenance actions were evaluated and were judged to be necessary for the continued reliable operation of the equipment. No additions or deletions to the PMS requirements are recommended.

A review of seven SARPs, the repair profile for the CG-16 Class, the repair profile for the CG-26 Class, and the repair requirements for BOH indicated that the industrial facility work normally performed on the main condensers and air ejectors was generally restricted to inspections and tests with little corrective maintenance being required.

On the basis of the results of this analysis, the main condensers and main air ejectors are expected to provide reliable service throughout the extended operating cycle and should require only routine PMS maintenance inspections during BOH and ROH periods. Routine corrective maintenance requirements are not anticipated. The maintenance policy for the main condensers should be a continuation of the present policy of running to failure, coupled with adherence to the PMS inspection requirements.

3.7.1.3 Recommendations

The following actions are recommended:

- Deal with corrective maintenance requirements on a case-by-case basis. These requirements will be infrequent, because maintenance on the main condensers and air ejectors during the operating cycle will consist primarily of performing the required PMS actions.

- Include an engineered task in the CMP for depot level accomplishment of ultrasonic testing of the condenser shell in accordance with PMS item MIP E-4/189-B7 (C-2) or MIP E-4/179-18 (C-2) during each ROH. This task should also be accomplished during BOH.

3.7.2 Auxiliary Condensers and Air Ejectors

3.7.2.1 Background

Each ship's service turbine generator (SSTG) has its own auxiliary condenser that condenses the exhausted steam in much the same manner as in the main condensers. Cooling water, to remove the latent heat of vaporization from the steam, is provided by the auxiliary salt water circulating system. A two-stage air ejector removes noncondensable gases from the auxiliary condenser. An electrically driven fan is used to exhaust these gases to the atmosphere from both SSTG sets for each engine room.

3.7.2.2 Discussion

The auxiliary condensers and air ejectors have been relatively trouble-free. The mean of the reported maintenance burdens shown in table 3-21 is 3.5 man-hours per component per operating year; this value is not considered excessive. The associated exhaust fans (APLs 400020121, 400020185, and 400120020) required an average of one man-hour per component per operating year (which is considered insignificant). Review of parts-usage data did not reveal repetitive usage of any significant parts for either the auxiliary condensers or their associated air ejectors. No pattern of equipment failures could be detected in the MDS data. The ship repair profiles

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for the CG-16 and CG-26 Classes did not include any maintenance actions that were routinely performed on the auxiliary condensers or air ejectors during shipyard overhaul periods. No CASREPs were issued on auxiliary condensers and air ejectors by any ships during the data period January 1972 to August 1978. The PMS requirements for the auxiliary condensers and air ejectors consist primarily of "clean and inspect" and "test" items. Although some of the PMS items are quite time-consuming (such as draining the saltwater side of the condenser and filling it with fresh water when the condenser will be idle for a week or more consumes about 10 man-hours), these items are considered necessary to assure continued satisfactory operation of these equipments. The existing PMS is considered adequate for this system.

On the basis of the results of this analysis, the auxiliary condensers and air ejectors have been shown to be reliable and can be expected to provide trouble-free operation throughout the extended operating cycle. The present maintenance strategy of accomplishment of PMS and performance of corrective maintenance only as required should be continued.

3.7.2.3 Recommendations

The only maintenance recommendations for the auxiliary condensers and air ejectors consist of performing the existing PMS requirements.

- Include an engineered task in the CMP for IMA accomplishment of testing condenser relief valves. This testing is to be done on a cyclic basis for CG-26, -27, -28, -32, and -34 as required by MIP E-4/188-B7, C-2. For all other ships of the CG-16 and CG-26 Classes, testing of the relief valves will be performed annually, as required by MIP E-4/188-38, A-10. This task should also be accomplished during BOH.
- Include an engineered task in the CMP for depot level accomplishment of ultrasonic inspection of the auxiliary condenser shell during each ROH period, as required by PMS items MIP E-4/180-38, C-1, and MIP E-4/188-B7, C-1. This task should also be a accomplished during BOH.

3.7.3 Auxiliary Gland Exhaust Condensers

3.7.3.1 Background

In order to recover the steam vented from the deaerating feed tank and expelled from the turbine glands of the main feed pumps and forced draft blowers, an auxiliary gland exhaust condenser is installed in each fireroom. The vapors condense in it and flow to the freshwater drain collecting tank. Air is removed from the gland exhaust condenser by a small motor-driven fan that provides a positive discharge through piping to the space ventilation exhaust system.

3.7.3.2 Discussion

The auxiliary gland exhaust condensers have been reliable and have not presented a significant maintenance burden. They have required an average of 12.8 man-hours of maintenance per component per operating year (see table 3-21). A review of the individual maintenance report narratives did not reveal any significantly recurring items. One condenser required replacement of all tubes and 272 total man-hours were expended by ship's force and IMA personnel, but major repairs, such as this one, were isolated. That single tube replacement task constitutes almost 10 percent of all the maintenance reported on all the auxiliary gland exhaust condensers of both the CG-16 and CG-26 Classes. No CASREPs were submitted on these gland exhaust condensers during the data period 1 January 1972 through 31 August 1978.

The auxiliary gland exhaust fans were another matter. Ship's force personnel report them as a significant maintenance problem: these fans are located high in the overhead of the fireroom where they are relatively inaccessible for maintenance and where the heat and humidity significantly degrade the performance and expected life of the motors. Thirteen CASREPs were submitted on the auxiliary gland exhaust condenser fans during the data period 1 January 1972 through 31 August 1978. Motor failures accounted for nine of the casualties, while the remaining four were caused by damaged impellers. The fans were manufactured by the Spencer Turbine Company and have been found to be unacceptable for their intended use. Parts-usage data confirms that evaluation, as fan impellers and motor bearings were replaced repetitively. Shipalts CG-16-1376D and CG-26-546D are designed to replace these close-coupled fans with new Spencer fans which will be overhanging units with couplings and separate motor and fan bearings. The motors will be replaced with Navy standard motors that are designed to withstand the heat. These shipalts will also relocate the fans to a more accessible location for maintenance and modify auxiliary machinery gland seal drains in order to reduce the possibility of water contamination of the lube oil and possible exhaust fan overloading. These shipalts are currently being prepared at PERA (CRUDES) and their accomplishment should significantly reduce the maintenance burden to this system.

The auxiliary gland exhaust condensers can be expected to provide reliable service through the extended operating cycle. A review of the repair profiles for the CG-16 and CG-26 Classes did not reveal any recurring maintenance required at the depot level. The PMS requirements for these condensers are minimal, but historical maintenance data indicate that the existing PMS requirements are adequate to support condenser operation. All PMS items can be performed by ship's force personnel. The performance of the new fans installed by shipalts CG-16-1376D and CG-26-546D cannot be evaluated, but the new fans are expected to provide far more reliable service than the presently installed units. The maintenance strategies for all of these condensers, fans, and motors should be to perform the recommended PMS actions and run the equipment to failure.

3.7.3.3 Recommendations

Shipalts CG-16-1376D and CG-26-546D should be accomplished during BOH. If these shipalts, together with the existing PMS requirements, are accomplished, satisfactory auxiliary gland exhaust condenser performance should be assured. No further maintenance actions are recommended for inclusion in the class maintenance plan.

3.8 FEED AND CONDENSATE SYSTEM (SWABs 255-1 through 255-7)

3.8.1 Description

The steam system of the CG-16 and CG-26 Class ships is a 1,200 psi closed system. The water that is changed into steam by the boilers and the water condensed from steam by the condensers are supplied to the boilers and removed from the condensers by the feed and condensate system. The feed subsystem contains the deaerating feed heater tanks; the main feed booster pumps, motors, and turbines; the main feed pumps and turbines; various main feed pump auxiliary equipments; and assorted piping and valves. The feed subsystem provides the boilers with the hot, deaerated feedwater necessary to maintain a constant water level in the boiler steam drum, regardless of steam demand. The condensate subsystem contains the main condensate pumps and turbines, the auxiliary condensate pumps, assorted motors and auxiliary equipments, and associated piping and valves. This subsystem removes the condensed steam from the main and auxiliary condensers and delivers it to the deaerating feed heater tanks, where it enters the feed system. Tables 3-22 and 3-23 present summaries of the MDS maintenance data reported against feed subsystem and condensate subsystem components of the CG-16 and CG-26 Classes; these tables will be referred to throughout this section.

3.8.2 Feed Subsystem

3.8.2.1 Main Feed Pumps

Six main feed pumps are installed in each CG-16 and CG-26 Class ship, three to each fireroom. The pumps installed in hulls CG-16 through CG-24 and CG-33 are Worthington model 5UWS 4-stage, turbine-driven, centrifugal pumps collocated with Worthington type JDH turbines on a common structural foundation. CG-26, -27, -28, -32, and -34 have Byron-Jackson model 5X6X8 type DVMX four-stage, turbine-driven centrifugal pumps installed with General Electric type DRV125N turbines. Ingersoll-Rand type 3DMA four-stage, turbine-driven, centrifugal pumps are installed with Terry Steam Turbine Company model BFBSC5 turbines on CG-29, -30, and -31. All of the pumps are connected to their respective turbines by a flexible coupling.

All of these pumps are similar in specification and are turbine-driven at sufficient speed to supply feedwater to the boiler at 75 psig above boiler steam pressure. The total discharge head of these pumps is rated at 1,445 to 1,460 psig. Two pumps in each fireroom are used for normal operation, while the third pump is kept ready as a backup unit.

Table 3-22. MDS BURDEN SUMMARY COMPARISON FOR FEED SUBSYSTEM EQUIPMENTS

Equipment	Class	APL	Population	Total Ship Operating Time (Ship Years)	JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Equipment per Operating Year
Main Feed Pumps	16	016031087	54	52.4	564	5,814	2,359	8,173	26.0
	26	016031087	6	7.1	69	811	273	1,084	25.4
		016180218	18	20.1	314	4,184	2,186	6,370	52.8
		017020021	30	33.2	500	4,252	3,560	7,812	39.2
Main Feed Pump Turbines	16	057300039	6	6.9	35	188	388	576	13.9
		057300044	48	45.4	336	4,465	2,520	6,985	25.6
	26	057300047	6	7.1	35	441	402	843	19.8
		057950085	18	20.1	136	2,079	839	2,918	24.2
		057260175	30	33.2	185	1,436	841	2,277	11.4
Main Feed Booster Pumps	16	016150378	54	52.4	446	4,287	2,944	7,231	23.0
	26	016150378	54	60.4	509	6,014	6,258	12,272	33.9
Main Feed Booster Pump Turbines	16	057700082	18	52.4	127	1,111	1,460	2,571	24.5
	26	None	0	-	-	-	-	-	-
Reserve Feed Transfer Pump and Vacuum Priming Pumps	16	016060107	18	52.4	54	1,146	155	1,301	12.4
		017070056	16	46.3	11	46	41	87	0.9
		017070072	2	6.0	0	0	0	0	0
	26	017030107	8	27.2	29	226	601	827	15.2
		016060107	10	27.9	29	444	281	725	13.0
		017070056	18	60.4	23	88	376	464	3.8
Main Feed Booster Pump Motors	16	174750518	36	52.4	13	281	197	478	2.3
	26	174802352	54	60.4	86	1,049	2,105	3,154	8.7
Reserve Feed Transfer Pump and Vacuum Priming Pump Motors	16	174750602	18	52.4	6	70	104	174	1.7
	26	174750602	10	33.2	8	25	49	74	1.1
		174802580	8	27.2	1	1	0	1	<1
DFT	16	074160051 074160052	18	52.4	178	1,326	1,035	2,361	22.5
	26	074160051 074160052	18	60.4	167	2,307	1,010	3,317	27.4

Table 3-23. MDS BURDEN SUMMARY COMPARISON FOR CONDENSATE SUBSYSTEM EQUIPMENT

Equipment	Class	APL	Population	Total Ship Operating Time (Ship Years)	JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Equipment per Operating Year
Main Condensate Pumps	16	016150379	36	52.4	243	2,949	2,497	5,446	26.0
	26	016150379	36	60.4	332	4,285	3,826	8,111	33.6
Main Condensate Pump Turbines	16	057700081	18	52.4	182	1,355	425	1,780	17.0
	26	None	0	-	-	-	-	-	-
Auxiliary Condensate Pumps	16	016000461	20	31.2	112	1,147	336	1,483	11.9
		016150391	4	6.6	11	128	56	184	7.0
		016020978	12	14.6	9	66	81	147	2.5
	26	016150465	36	60.4	80	632	337	969	4.0
Main Condensate Pump Motors	16	174750756	18	52.4	14	220	255	475	4.5
	26	174802353	36	60.4	52	706	601	1,307	5.4
Auxiliary Condensate Pump Motors	16	174750769	4	6.6	9	163	108	271	10.3
		174752156	20	31.2	9	5	0	5	<1
		174180288	12	14.6	5	40	124	164	2.8
	26	175503457	36	60.4	30	284	136	420	1.7

Worthington Main Feed Pumps

Background. The Worthington main feed pumps are installed in all CG-16 Class ships and in CG-33, and are supported by allowance parts list (APL) 016031087.

MDS Summary. From the summary of MDS burden data presented in table 3-22 it can be seen that the average man-hour burden per pump per operating year for APL 016031087 was about the same in both classes (26.0 versus 25.4 man-hours per equipment per operating year). A review of the MDS narrative transaction data for this pump determined that a majority of these man-hours was reported for replacement of major wearing parts. It often cannot be determined from that data which of the replaced parts induced the failure because, for convenience, many parts are replaced while a pump is open. For this analysis, therefore, significant pump repairs and the man-hour burden associated with those repairs were identified. A significant repair was defined as repair or replacement of one or more of the following:

- Bearings
- Wearing rings
- Casing
- Shaft
- Rotor assembly
- Impeller

From the MDS narrative transaction data a statistic called the mean time between significant repairs (MTBSR) was calculated, using the formula

$$MTBSR = \frac{\text{Pump-Operating Years (POY)}}{\text{Number of Significant Repairs}}$$

The MTBSR has the units of pump operating years per significant repair, and represents the average time between significant repairs of a pump at the ship's force or IMA level. For the Worthington pump, the MTBSR was

$$\frac{\text{357 SOY}}{\text{53 S.R.}} = \frac{\text{6.7 Pump Operating Years}}{\text{Significant Repairs}}$$

or about 81 pump operating months between significant repairs. The man-hour burden associated with these 53 significant repairs totaled 3,103 man-hours, of which ships' forces reported 2,580 man-hours (83 percent of total man-hours) and IMAs reported 523 man-hours (17 percent of total man-hours). These statistics indicate that ship's force exhibited the capability to make most of the significant main feed pump repairs, with IMA assistance required for some repairs. Each significant repair required an average of about 58 man-hours to complete, or slightly more than three and one-half days if two men each worked eight hours per day.

Parts-Usage Summary. MDS parts-usage data summaries show that, except for consumables such as packing and gaskets, parts usage was low in relation to total individual part populations. This relationship is especially true of the major wearing parts included within the definition of a significant repair; such parts include wearing rings, impellers, and rotor assemblies (all of which experienced nonrepetitive random usage during the data period). Such usage substantiates the conclusion that significant main feed pump repairs are unlikely to be required during a 60-month operating cycle.

CASREP Summary. A review of CASREP data for the period 1 January 1976 through 31 August 1978 identified eight CASREPs submitted against the Worthington main feed pumps, corresponding to one CASREP every 20 pump-years. Seven of these eight CASREPs had a severity of C-2, which indicated minor degradation of a primary ship mission, while the other CASREP had a severity of C-3, which indicated major mission degradation. Note that the redundant installation of main feed pumps reduces the criticality of main feed pump failures. CASREPs were reported by four of ten ships with the Worthington pump, indicating that failures causing mission degradation have not occurred on all applicable ships. Of the failures reported in the CASREPs, vibration, journal wear, and other bearing-related failures were the most prevalent; these failures accounted for five of the eight CASREPs. Failed seals and excessive clearances on internal parts accounted for the other three CASREPs.

It is concluded from the CASREP review that there has been only minor degradation of ships' missions caused by main feed pump failures, that spare parts support has been adequate, and that downtime awaiting maintenance has been an infrequent minor problem. Judging from the CASREP submission rate, mission degrading failures are not likely to have a significant effect on a ship's capability to complete an extended operating cycle. It is further concluded, therefore, because of the low CASREP submission rate and the redundant pump installation, that the significance of a main feed pump failure is low.

PMS Summary. The Worthington main feed pump (APL 016031087) is maintained according to maintenance index page (MIP) F-13/76-78. Main feed pump turbine maintenance is also specified by this MIP, which is comprehensive and includes several condition assessment requirements. These include measurements of bearing clearances and tests of relief-valve lifting pressures. Also included are cyclic requirements to inspect pump internal parts (MRC F-13 C-1) and journal and thrust bearings (MRC F-13 C-4). These requirements should continue to be used as troubleshooting tools when pump performance is degraded and the specific repairs required need to be determined.

ROH Repair History and DDEOC BOH Repair Requirements. CG-16 and CG-26 Class repair profiles (dated November 1975 and October 1975, respectively) both recommend routine class B overhaul of all six main feed pumps and turbines during ROH. In both repair profiles it was reported that these overhauls appeared in five of five ship alteration and repair packages (SARPs). The DDEOC BOH repair requirements for the CG-16 and CG-26 Classes

also list these routine overhauls and specify that the overhauls should be accomplished in accordance with the applicable technical repair standard. Class B overhauls of all six main feed pumps are also SURFLANT and SURFPAC routine items. However, the reported MDS and CASREP data do not support the necessity for overhauling the six main feed pumps on a routine basis. The analysis has shown that ship's force is capable of performing significant repairs, with some assistance from IMAs. CASREP submissions, and thus the significance of failure, have been low, as has been the usage of major wearing parts between ROHs. It is therefore concluded that the policy of performing class B overhauls of all six main feed pumps during each ROH is not justified as a routine repair. This analysis has shown, however, that main feed pumps have required some major repairs between ROHs. It is judged reasonable then to anticipate that the condition of some main feed pumps will have degraded sufficiently during the operating cycle to affect mission performance. Therefore, the condition of the main feed pumps should be determined by POT&I and CSMP before BOH and ROH, and repairs should be based on this determination. In anticipation that some pumps will require overhaul rather than simple repairs, a reservation should be included in the CG-16 and CG-26 Class maintenance plans for the restoration of three of six Worthington main feed pumps to class B standards, in accordance with the applicable TRS, during BOH and ROH. The other three of a ship's six pumps should be repaired as shown to be necessary by the POT&I results and the CSMP. The main feed pumps should be maintained during the intracycle on a run-to-failure basis by ship's force, with assistance provided by IMAs as necessary.

Recommendatio... The following recommendations are made:

- Include in the CG-16 and CG-26 Class maintenance plans (CMPs) qualified tasks for a depot activity to repair the main feed pumps as shown to be necessary by the POT&I and each ship's CSMP. Anticipate that three of a ship's six main feed pumps will require overhaul, which should be accomplished in accordance with TRS 0255-086-643, and include the overhauls in the CMPs as qualified task reservations for depot accomplishment during ROH. Make repairs on the same basis during BOH.
- During the intracycle, maintain the Worthington main feed pumps according to a run-to-failure maintenance strategy, with repairs to be accomplished by ship's force, and IMA assistance to be provided as necessary.
- Delete the requirements for routine overhauls of all six main feed pumps at BOH from the CG-16 and CG-26 Class DDEOC repair requirements for BOH.
- Use MRCs F-13 C-1 and F-13 C-4 during the operating cycle as a troubleshooting tool to identify specific main feed pump repairs when less than adequate pump performance is experienced or when known pump degradation has occurred.

Byron-Jackson Main Feed Pumps

Background. The Byron-Jackson main feed pumps are installed in CG-26, -27, -28, -32, and -34 and are supported by APL 017020021.

MDS Summary. An average of 39.2 man-hours per equipment per year were reported against this pump in the MDS data (see table 3-22). This rate is higher than the burden reported against the Worthington pump, but lower than the burden reported against a similar pump installed on certain DDG-37 Class ships. As with the Worthington pump, a review of the MDS narrative transaction data showed that a majority of the man-hours were reported for replacement of major wearing parts. The resulting mean time between these 50 significant repairs was about 48 pump-months per significant repair. A total of 2,581 man-hours were expended in making those significant repairs. Of that total, 1,475 man-hours (57 percent of total man-hours) were reported by ship's force and 1,106 man-hours (43 percent of total man-hours) were reported by IMAs. Thus pump repairs have been accomplished primarily by ships' forces, but major IMA assistance has been required. Each significant repair required an average of 52 man-hours to complete, or slightly more than three days if two men each worked eight hours per day.

Parts-Usage Summary. Usage of major wearing parts such as wearing rings, impellers, and rotor assemblies has been repetitive (see table 3-24). The parts-usage data led to the conclusion that replacement of major wearing parts and the resultant substantial man-hour expenditures are likely during a 60-month operating cycle.

CASREP Summary. A review of CASREP data for the period 1 January 1976 through 31 August 1978 identified four CASREPs submitted against the Byron-Jackson main feed pumps, which corresponds to one CASREP every 20 pump-years. Three of the four CASREPs were submitted for excessive clearances or wear. The fourth CASREP was submitted for lube oil leakage past a seal, which constituted a safety hazard. All four CASREPs had a severity of C-2, indicating minor degradation of ship primary missions and were reported by three of five applicable ships. The three CASREPs that reported either wear or excessive clearance show that failures resulting in significant main feed pump repairs seldom cause more than minor ship mission degradation. Thus it is concluded that the significance of a main feed pump failure is low.

Downtime reported in the four CASREPs totaled 5,594 hours (233 days) for an average of 1,398 hours (58 days) per CASREP. Most of the downtime (65 percent of total downtime or 3,640 hours) was reported awaiting maintenance. Downtime hours awaiting supply totaled 1,954 hours (81 days) in only two CASREPs, for an average of 977 hours (41 days) per CASREP. There was no downtime awaiting supply reported in the other two CASREPs. Because of the few CASREPs submitted and because only half of those submitted reported any downtime awaiting supply, it is concluded that except in isolated cases, parts support for the Byron-Jackson main feed pumps has been adequate.

Table 3-24. BYRON-JACKSON MAIN FEED PUMP (APL 017020021) PARTS – USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
9C-4320-00-950-9305	Impeller wearing ring	2	60	30	50	5
9C-4320-00-950-9306	Impeller wearing ring	2	60	36	60	5
9C-4320-00-950-9307	Impeller wearing ring	4	120	63	52	5
9C-4320-00-977-2781	Casing wearing ring	4	120	70	58	5
9C-4320-00-977-2782	Casing wearing ring	2	60	44	73	5
9ZS3120-00-977-2785	Sleeve bearing	2	60	45	75	5
9C-4320-00-977-2793	Wearing ring	2	60	24	40	4
9C-4320-00-977-2794	Shaft sleeve	1	30	28	93	5
9C-4320-00-977-2795	Shaft sleeve	1	30	23	77	5
1HM4320-00-977-2803	Thrust bearing shoe	1 set	30 sets	20 sets	67	5

On the basis of the findings from the CASREP review and analysis, it is concluded that there has been only minor degradation of ships' mission caused by main feed pump failures, that parts support has been generally adequate, that downtime awaiting maintenance has been a minor problem, and that the significance of failure of the Byron-Jackson main feed pumps has been low. Thus mission degrading failures are not likely to have a significant effect on a ship's capability to complete an extended operating cycle.

PMS Summary. Maintenance requirements for the Byron-Jackson main feed pump are delineated by MIP F-13/39-B7. As with the Worthington main feed pump, the maintenance requirements for the associated turbines are also specified by the pump MIP. Several condition assessment requirements, such as measurement of bearing clearances, are included in this comprehensive MIP, as well as requirements to inspect internal parts (MRC F-13 U-17) and journal and thrust bearings (MRC F-13 C-3). MRCs U-17 and C-4 are to be scheduled for accomplishment during shipyard overhaul according to notes listed on the MIP. Judging by the MTBSR of about 48 months for this pump, the periodicity of these requirements would appear to be too long for a 60-month operating cycle. However, because the significance of main feed pump failures has been shown to be low, scheduling these inspections earlier than ROH does not appear justified, especially considering the combined ship's force and IMA capability to make significant repairs. Continued use of these MRCs as troubleshooting tools to identify specific repairs necessary during the intracycle is recommended when less than adequate pump performance is experienced.

ROH Repair History and DDEOC BOH Repair Requirements. Subsection 3.8.2.1 of this report explained that both CG-16 and CG-26 Class repair profiles and the CG-16 and CG-26 Class DDEOC BOH repair requirements specify routine class B overhauls of six of six main feed pumps and turbines during ROH and BOH. It was also explained in that subsection that even though the overhauls are routine repair items required by SURFPAC and SURFLANT type commanders, the MDS and CASREP data do not support accomplishing these overhauls as routine repairs. This conclusion also applies to the Byron-Jackson pumps because of the identified ship's force and IMA repair capability, as well as the low significance of main feed pump failure. Although the narrative transaction and parts-usage data indicate that some significant repairs are likely to be required during the intracycle, the small number and low submission rate of CASREPs indicate that there will be little effect on a ship's mission resulting from main feed pump failure. Therefore, the Byron-Jackson main feed pumps should be maintained during the intracycle by ship's forces and IMAs using a run-to-failure strategy, and because some degradation of main feed pumps is probable during the intracycle, the pumps should be subjected to a POT&I before BOH and ROH. Any repairs required during BOH and ROH should be defined on the basis of the POT&I results and each ship's CSMP. In anticipation of a need to overhaul some of the main feed pumps during BOH and ROH, a reservation should be included in the CG-26 Class CMP for class B overhauls of three of a ship's six pumps, to be accomplished by a depot activity in accordance with TRS 0255-086-649. This reservation also applies to BOH.

Recommendations. The following actions are recommended:

- Include in the CG-26 CMP a qualified task for a depot activity to repair the main feed pumps during ROH as shown to be necessary by the POT&I results and each ship's CSMP. Anticipate that three of a ship's six main feed pumps will require overhaul, which should be accomplished in accordance with TRS 0255-086-649, and include the overhaul in the CMP as a qualified task reservation for depot accomplishment during ROH. Make repairs on this same basis during BOH. Implementation of this strategy will place the main feed pumps on (essentially) a 120-month overhaul cycle.
- During the intracycle, maintain the Byron-Jackson main feed pumps by using a run-to-failure maintenance strategy, with repairs to be accomplished by ship's force and by IMAs when necessary.
- Delete the requirement for routine overhauls of all six main feed pumps during BOH from the CG-26 Class DDEOC BOH repair requirements.
- Continue to use MRCs F-13 U-17 and F-13 C-4 as troubleshooting tools to identify specific main feed pump repairs necessary during the intracycle when less than adequate pump performance is experienced.

Ingersoll-Rand Main Feed Pumps

Background. Ingersoll-Rand main feed pumps are installed in hulls CG-29, -30, and -31 and are supported by APL 016180218.

MDS Summary. From the summary of MDS data presented in table 3-22, it can be seen that the average man-hour burden per pump per operating year was about twice that of the Worthington and Byron-Jackson pumps installed on the CG-16 Class and CG-26 Class ships. A review of the MDS transaction data for this pump determined that a majority (about 58 percent) of the total man-hours were reported for replacement of major wearing parts. The resulting mean time between significant repairs was about 13 pump-months per significant repair. A total of 3,690 man-hours were reported for those 116 significant repairs of which 2,629 man-hours (71 percent of total man-hours) were reported by ship's forces and 1,061 man-hours (29 percent of total man-hours) were reported by IMAs. Thus repairs of these pumps are normally accomplished by ship's forces, with occasional assistance provided by IMAs. Each of the significant repairs required an average of about 32 man-hours to complete, or about two days if two men each worked eight hours per day.

Parts-Usage Summary. Usage of Ingersoll-Rand main feed pump wearing parts was repetitive (see table 3-25). Usage of shaft sleeves and bushings was higher on a percentage of population basis than usage of wearing rings and rotor assemblies, indicating that pump performance has not been a limiting factor in requiring repairs. Because of this reported parts usage, it is concluded that wearout and replacement of major wearing parts

Table 3-25. INGERSOLL-RAND MAIN FEED PUMP (APL 016180218) PARTS – USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
9Z-3120-00-067-9488	Throat bushing	1	18	11	61	2
2HH4320-00-076-9147	Rotor assembly	1	18	6	33	3
9C-4320-00-076-9149	Wearing ring	2	36	17	47	3
9C-4320-00-076-9150	Wearing ring	2	36	15	42	3
9Z-3120-00-076-9151	Sleeve bushing	1	18	12	67	3
9C-4320-00-076-9152	Shaft sleeve	2	36	26	72	3
9Z-3120-00-076-9154	Sleeve bearing	1	18	13	72	3

is likely during a 60-month operating cycle and that usage of shaft sleeves and bushings will be higher than usage for wearing rings and rotor assemblies.

CASREP Summary. A review of CASREP data for the period 1 January 1976 through 31 August 1978 identified three CASREPs submitted against the Ingersoll-Rand main feed pumps, corresponding to a rate of one CASREP every 17 pump-years. This submission rate is comparable to that experienced by the Worthington and Byron-Jackson main feed pumps installed on the other CG-16 and CG-26 Class ships. All three CASREPs had a severity of C-2, which indicates that only minor degradation of a primary ship mission had occurred. Three different failures were reported on the CASREPs, screw failure (wearing ring attaching set screw) causing a frozen rotor, seized wearing ring, and vibration. CASREPs were reported by two of the three applicable ships, indicating that mission degrading main feed pump failures have not occurred on all ships.

A total of 2,640 hours were reported for equipment downtime for an average of 880 hours down per CASREP. Of this total, 1,464 hours (55 percent of total downtime) was reported in one CASREP for downtime awaiting supply. The other 1,176 hours (45 percent of total downtime) were reported for downtime awaiting maintenance. Therefore, because only three CASREPs were submitted and because downtime awaiting supply was reported in only one CASREP, it is concluded that mission degrading main feed pump failures are not likely to be a significant factor during an extended operating cycle, that supply support is adequate (except in isolated cases), and that downtime awaiting maintenance has not materially degraded ship performance. It is further concluded, therefore, that the significance of main feed pump failure is low.

PMS Summary. MIP F-13/84-77 defines the maintenance requirements for the Ingersoll-Rand main feed pump and for its associated turbine, similar to the Worthington and Byron-Jackson main feed pump MIPs. As with the MIPs for the other pumps, several condition assessment MRCs, such as clearance measurements and relief-valve-lifting-pressure-checks, are included on this MIP. There is also a cyclic periodicity requirement (MRC F-13 C-1) to inspect pump internal parts, with mandatory scheduling required by the MIP. Because the experienced time between significant repairs for the Ingersoll-Rand main feed pump is about 13 pump-months between significant repairs, it appears that this requirement is superfluous. However, the MRC can still be used to identify required repairs for ROH. Scheduling more frequent accomplishment of this MRC does not appear justified, considering ship's forces capability to make repairs with IMA assistance and the indicated low significance of main feed pump failure. Continued use of MRC F-13 C-1 as a troubleshooting tool to identify specific repair requirements necessary during the operating cycle is recommended when less than adequate pump performance is experienced.

ROH Repair History and DDEOC BOH Repair Requirements. Subsection 3.8.2.1 explained that both CG-16 and CG-26 Class repair profiles and the CG-16 and CG-26 Class DDEOC BOH repair requirements specify routine class B overhauls of six of a ship's six main feed pumps and drivers during ROH

and BOH. It was also explained in that subsection that even though the overhauls are routine repair items required by SURFPAC and SURFLANT type commanders, the MDS and CASREP data do not support accomplishing these overhauls as routine repairs. This conclusion also applies to the Ingersoll-Rand main feed pumps because of the identified ship's forces repair capability and the low significance of main feed pump failure. Although the narrative transaction and parts-usage data indicate that significant repairs are likely to be required during the intracycle, the small number and low submission rate of CASREPs indicate that there will be little degradation of primary ship's missions resulting from main feed pump failure. Therefore, the Ingersoll-Rand main feed pumps should continue to be maintained during the intracycle by ship's forces and IMAs using a run-to-failure strategy. Because degradation of the main feed pumps is likely to occur during the intracycle, the main feed pumps should be subjected to a POT&I before BOH and ROH. Any repairs required during BOH and ROH should be defined on the basis of the POT&I results and each ship's CSMP. In anticipation of a need to overhaul some of the main feed pumps during BOH and ROH, a reservation should be included in the CG-26 CMP for class B overhauls of three of a ship's six main feed pumps, to be accomplished during ROH by a depot activity in accordance with TRS 0255-086-650. This reservation applies also to BOH. Implementation of this strategy will place the main feed pumps on (essentially) a 120-month overhaul cycle.

Recommendations. The following recommendations are made:

- Include in the CG-26 CMP a qualified task for a depot activity to repair the main feed pumps as shown to be necessary by the POT&I results and each ship's CSMP. Anticipate that three of a ship's six main feed pumps will require overhaul, to be accomplished in accordance with TRS 0255-086-650, and include the overhaul in the CMP as a qualified task reservation for depot accomplishment during ROH. These tasks are applicable during BOH.
- During the intracycle, maintain the Ingersoll-Rand main feed pumps by using a run-to-failure maintenance strategy, with repairs to be accomplished by ship's force, and IMA assistance to be provided as required. Continue to use MRC F-13 C-1 as a troubleshooting tool to identify specific main feed pump repair requirements during the intracycle when less than adequate pump performance is experienced.
- Delete the requirement for routine overhaul of all six main feed pumps during BOH from the CG-26 Class DDEOC BOH repair requirements.

3.8.2.2 Main Feed Pump Turbines

Description

The six main feed pumps installed on each of the CG-16 and CG-26 Class ships are driven by steam turbines. Worthington type JDH single-wheel

turbines are installed on all CG-16 Class ships and on CG-33. Hulls CG-26, -27, -28, -32, and -34 have General Electric type DRV125N turbines, while hulls CG-29, -30, and -31 have Terry Steam Turbine Company BFBSC5 turbines installed. All are single stage turbines and are driven by 1,200 psi superheated steam. Turbine speed is regulated by steam admission valves, which are controlled by the automatic feedwater control system. A flexible coupling connects the turbine to its associated pump; both turbine and pumps are mounted on the same foundation. The subsections that follow will describe the historical maintenance experience of the three main feed pump turbine designs and will recommend BOH and ROH repairs and a DDEOC maintenance strategy.

Worthington Main Feed Pump Turbines

Background. Worthington type JDH main feed pump turbines drive Worthington main feed pumps and are installed in all CG-16 Class ships and in CG-33. These turbines are supported by APLs 057300039 (CG-21), 057300044 (all other CG-16 Class ships), and 057300047 (CG-33). Although supported by different APLs, the installed turbines are virtually identical and are addressed together in this report. Therefore, the resulting recommendations apply to all three APLs.

MDS Summary. Table 3-22 presents a summary of the MDS data reported against the individual APLs that support the Worthington main feed pump turbines. On an aggregate basis, the turbines had a reported burden of 406 JCNs, 5,094 ship's force man-hours, and 3,310 IMA man-hours, for a total of 8,404 man-hours and an average of 23.6 man-hours per turbine per operating year. Unlike the associated main feed pump, however, this burden was not the result of major repairs. There were very few JCNs in which major repairs were accomplished, which indicates that the turbines suffered few major failures during the data period. Other than PMS deferrals, JCNs in which the maintenance performed was not defined, and safety-related required work (such as the installation of lube oil strainer shields), only repairs of steam admission valves and servomotors could be considered repetitive. These repairs accounted for 45 JCNs (11 percent of total JCNs), 1,381 ship's force man-hours (27 percent of total ship's force man-hours), and 51 IMA man-hours (2 percent of total IMA man-hours). Overall, steam admission valve and servomotor repairs accounted for 17 percent of the ship's force and IMA man-hours reported against the Worthington main feed pump turbines. Failures of these components included stem binding and failing to close for the steam admission valve, and erratic operation for the servomotor. Occurrence of these failures was confirmed by ship's forces during a discussion held aboard the USS DALE (CG-19). The mean time between these significant repairs was calculated to be about eight turbine-years per repair, or much longer than a 60-month operating cycle. Modifications to the Worthington steam admission valve, which should eliminate the stem binding and failure-to-close problems, are specified in shipalts CG-16-1281D and CG-26-463D. Unless previously installed, these shipalts should be installed during BOH. No established solution exists for the erratic operation of the servomotor.

Parts-Usage Summary. Other than usage of consumable parts such as gaskets, parts usage for the Worthington main feed pump turbines was not repetitive. It is therefore judged that replacement of turbine parts other than consumable parts will be at a minimum during an extended operating cycle.

CASREP Summary. A total of 21 CASREPs were submitted against the turbines, which is a submission rate of one CASREP every eight turbine-years for the period 1 January 1976 through 31 August 1978. Nineteen of these CASREPs were submitted for failure of either the steam admission valve or the servomotor, or for oil leaks or lack of oil pressure to the servomotor. Fifteen of the 19 CASREPs had a severity code of C-2, indicating only minor mission degradation. The other four of the 19 CASREPs submitted had severity codes of C-3 (three CASREPs) and C-4 (one CASREP), indicating that major mission degradation had occurred; these four CASREPs were submitted by CG-33 over a four-month period. The submissions of these CASREPs with severity codes C-3 and C-4 by one ship over a short period is unusual when compared to the other ships' experiences and is not representative of the class behavior. However, these submissions show that ship's force occasionally consider that major mission degradation results from steam admission valve or servomotor failures. The other two CASREPs were submitted for misalignment of the turbine and failed bearings. Both of these CASREPs had a severity code of C-2, indicating only minor mission degradation. It is concluded from these data that the rotating turbine assembly has not resulted in any degradation of ships' primary mission areas and that any degradation of ships' missions has been the result of the steam admission valve and servomotor failures. It is further concluded that mission-degrading failures of the steam admission valve and servomotor are more likely to occur during an extended operating cycle than failures of the rotating turbine assembly. Because of the low CASREP submission rate for rotating assembly failures, and the redundant main feed pump and main feed pump turbine installations, the significance of main feed pump turbine rotating assembly failure is low.

PMS Summary. The Worthington main feed pump turbines are maintained according to the MRCs included on MIP F-13/76-78. As explained in subsection 3.8.2.1, this MIP is comprehensive and includes several condition assessment tests such as thrust clearance measurements, gland clearance measurements, and lube oil samplings and inspections. More importantly, there are two MRCs that, if conscientiously performed, should minimize the number of steam admission valve failures. MRC F-13 Q-20 specifies a quarterly test of the steam admission valve, with MRC F-13 U-5 to be performed on the basis of the test results. MRC F-13 U-5 is an unscheduled requirement for ship's force to disassemble and inspect the steam admission valve, with subsequent repairs defined by the work center supervisor. Because these PMS requirements must be used on a periodic basis to assess the steam admission valves' condition and define subsequent repairs, and because the significance of main feed pump turbine failure has been shown to be low, it is judged that establishing additional scheduled steam admission valve maintenance is not required.

ROH Repair History and DDEOC BOH Repair Requirements. Subsection 3.8.2.1 of this report describes in detail the CG-16 and CG-26 Class repair profile history, DDEOC BOH repair requirements, and SURFPAC and SURFLANT type commander routine turbine repair items scheduled for accomplishment during ROH. In all cases, routine overhauls of all six main feed pumps and main feed pump turbines are required. However, this analysis has shown that there have been no reported failures of the turbine's rotating assemblies, nor any failures that caused any degradation of a ship's primary mission. It is concluded, therefore, that the turbines have operated reliably throughout the data period and that the routine overhaul of all six main feed pump turbines is not justified.

It has been shown that a substantial amount of maintenance has been required to correct steam admission valve and servomotor failures, that those failures have caused degradation of ship's primary missions, and that steam admission valve and servomotor failures are likely to occur during an extended operating cycle. Therefore, the steam admission valves and servomotors should be overhauled during BOH in conjunction with the installations of either shipalt CG-16-1281D or shipalt CG-26-463D. Steam admission valve and servomotor repairs should be accomplished during ROH on the basis of the inspection defined by MRC F-13 U-5, the POT&I of the entire turbine, and each ship's CSMP.

Anticipating that some repairs may be required during BOH and ROH, the main feed pump turbines should be subjected to POT&Is before BOH and ROH, with repairs accomplished on the basis of the POT&I results and each ship's CSMP. If it is determined that turbine overhauls are required, the overhauls should be accomplished in accordance with TRSs 0255-086-613 (APL 057300044) or 0255-086-652 (APL 057300047), or to class B standards (APL 057300039). During the operating cycle, the turbines should be maintained by using a run-to-failure maintenance strategy, with repairs to be accomplished by ship's forces and IMA assistance to be provided as required.

Recommendations. The following actions are recommended:

- Include in the CG-16 and CG-26 Class maintenance plans (CMPs) qualified tasks for a depot activity to repair the main feed pump turbines on the basis of the POT&I results and each ship's CSMP. If a turbine overhaul is determined to be required, the overhaul should be accomplished in accordance with TRSs 0255-086-613 (APL 057300044) or 0255-086-652 (APL 057300047) or to class B standards (APL 057300039).
- Perform a class B overhaul on the Worthington main feed pump turbine steam admission valves and servomotors during BOH in conjunction with the accomplishment of shipalt CG-16-1281D or shipalt CG-26-463D. Repairs required during ROH will be identified by the inspection defined by MRC F-13 U-5, the POT&I of the entire turbine, and each ship's CSMP. Include a qualified task for depot accomplishment in the CG-16 and CG-26 CMPs to accomplish this task during ROH.

- Delete the requirements for the routine overhaul of all six main feed pump turbines during BOH from the CG-16 and CG-26 Class DDEOC BOH repair requirements.
- During the intracycle, maintain the Worthington main feed pump turbines using a run-to-failure maintenance strategy, with repairs to be made by ship's forces, and IMA assistance to be provided as required.
- Investigate the failures and erratic operation of the servomotor and develop an alteration to correct the problems.

General Electric Main Feed Pump Turbines

Background. General Electric (GE) type DRV125N main feed pump turbines drive Byron-Jackson main feed pumps and are installed in hulls CG-26, -27, -28, -32, and -34. These turbines are supported by APL 057260175.

MDS Summary. A summary of the MDS maintenance data reported against the GE main feed pump turbine is presented in table 3-22. Similar to the Worthington main feed pump turbine, the burden reported against the GE turbine was distributed among several nonrepetitive failure modes with none of those failure modes predominating. Ship's forces accounted for about 63 percent of the man-hours reported against the turbine, while IMAs reported the rest. It is concluded from the data, therefore, that there have been few GE main feed pump turbine failures requiring major expenditures of man-hours, that the likelihood of such failures occurring during an extended operating cycle is small, and that ships' forces are capable, with some IMA assistance, of maintaining the GE turbines during the operating cycle.

Parts-Usage Summary. There were no GE main feed pump turbine repair parts, other than consumables, used during the data period. Replacement of turbine parts, other than consumables, will be at a minimum during an extended operating cycle.

CASREP Summary. Two CASREPs were submitted against the GE main feed pump turbines during the period 1 January 1976 through 31 August 1978. One was for worn thrust shoes and one was for failed labyrinth packing. Downtime for these two CASREPs totaled 932 hours (about 39 days), of which 720 hours (30 days) or 71 percent of total downtime was spent awaiting supply. It is judged that because of the low CASREP submission there has been essentially no degradation of primary ship missions. Therefore, it is concluded that mission degrading turbine failures are not likely to occur during an extended operating cycle.

PMS Summary. The GE main feed pump turbines are maintained according to MIP F-13/39-B7, which is comprehensive in its delineation of required tests and inspections. Because the GE turbine has operated reliably during the data period, it is concluded that no changes need to be made to this MIP to ensure acceptable main feed pump turbine performance during an extended operating cycle.

ROH Repair History and DDEOC BOH Repair Requirements. Subsection 3.8.2.1 of this report describes in detail the CG-26 Class repair profile history, the DDEOC BOH repair requirements, and the SURFPAC and SURFLANT type commander routine repair items normally scheduled for accomplishment during ROH. In all these documents, the routine overhaul of all six main feed pump turbines is specified. However, this analysis has shown that the GE turbines operated reliably throughout the data period, experienced few major failures, and that essentially no mission-degrading failures have occurred. It is concluded, therefore, that the routine overhaul of all six main feed pump turbines is not justified. To define the repairs to be accomplished during BOH and ROH, each main feed pump turbine should be subjected to a POT&I and should be repaired on the basis of the POT&I results and each ship's CSMP. If an overhaul is determined to be required, it should be accomplished in accordance with TRS 0255-086-651. The turbines should be maintained during the intracycle by ship's forces, with IMA assistance provided as required, by using a run-to-failure maintenance strategy.

Recommendations. The following actions are recommended:

- Include a qualified task in the CG-26 CMP for a depot activity to repair the main feed pump turbines on the basis of the POT&I results and each ship's CSMP. If a turbine overhaul is determined to be required, the overhaul should be accomplished in accordance with TRS 0255-086-651.
- Delete the requirement for the routine overhaul of all six main feed pump turbines from the CG-26 Class DDEOC BOH repair requirements.
- Maintain the General Electric main feed pump turbines during the intracycle by using a run-to-failure maintenance strategy. Corrective maintenance should be performed by ship's force, with IMA assistance provided as required.

Terry Steam Turbine Company Main Feed Pump Turbines

Background. Terry Steam Turbine Company (hereafter known as "Terry") main feed pump turbines drive Ingersoll-Rand main feed pumps and are installed in hulls CG-29, -30, and -31. These turbines are supported by APL 057950085.

MDS Summary. Table 3-22 presents a summary of the MDS maintenance data reported against the Terry main feed pump turbines during the data period. Of the three turbine designs installed on CG-16 and CG-26 Class ships, the Terry turbine had one of the highest average man-hour burdens per turbine per operating year, and was only slightly lower than one Worthington turbine APL. Two failure modes accounted for a substantial (1,626 man-hours or 56 percent) portion of the total reported man-hours. These failures were leakage and erratic operation of steam admission valves and servomotors, and bearing and lube oil system failures.

The man-hour burden for the 37 steam admission valve and servomotor repairs totaled 914 man-hours, and averaged 25 man-hours per significant repair. A total of 712 man-hours was reported for the 27 bearing and lube oil repairs, for an average of 26 man-hours per repair. On an aggregate basis the 64 steam admission valve and servomotor and bearing and lube oil repairs totaled 1,626 man-hours; these repairs were accomplished at a rate of three repairs per ship per operating year. It is concluded that there has been a substantial man-hour burden reported against the Terry main feed pump turbines for repairs of steam admission valve and servomotor and bearing and lube oil system failures, and that those failures are likely to occur during an extended operating cycle. Other than for the steam admission valve and servomotor, the turbine has operated reliably throughout the data period.

Parts-Usage Summary. Reported parts usage for the Terry main feed pump turbine was nonrepetitive, except for consumables such as O-rings, packing, and gaskets. Other than consumables, it is likely that replacement of turbine parts will be at a minimum during the operating cycle.

CASREP Summary. A total of eight CASREPs were submitted against Terry turbines during the period 1 January 1976 through 31 August 1978, which is a submission rate of one CASREP every six turbine-years. All of the CASREPs were submitted for failure of either the steam admission valve or the servomotor; none were submitted for failures of the rotating turbine assembly. The steam admission valve and servomotor failures reported in the CASREPs included erratic operation, sticking, and leaking. Downtime for the failures totaled 8,376 hours (349 days), which is an average of 1,047 hours (about 44 days) per CASREP. All of the downtime was reported awaiting maintenance; there was no downtime reported awaiting supply. Because there were no CASREPs submitted for rotating turbine assembly failures, it is concluded that there has been no degradation of ships' primary missions as a result of rotating turbine assembly failure. The severity code of C-2 was reported for all of the eight CASREPs submitted, which shows that there has been only minor degradation of ships' primary missions from steam admission valve and servomotor failure. On the basis of the repetitive repairs reported in the MDS and the CASREP submissions exclusively for steam admission valve and servomotor failures, it is likely that similar failures and repairs will occur during an extended operating cycle. Because of the redundant main feed pump and main feed pump turbine installations and the low CASREP submission rate, it is concluded that the significance of turbine failure is low.

PMS Summary. The Terry main feed pump turbines are maintained according to MIP F-13/84-77, which is comprehensive in its delineation of required tests and inspections. However, there are no specific tests or inspections of the steam admission valve or servomotor. The addition to MIP F-13/84-77 and conscientious performance of MRCs F-13 Q-20 and F-13 U-5 (see subsection 3.8.2.2 for a description) is recommended in order to define specific inspections and tests of those components and to minimize the number of steam admission valve and servomotor failures.

ROH Repair History and DDEOC BOH Repair Requirements. Subsection 3.8.2.1 of this report describes in detail the CG-26 Class repair profile history, the DDEOC BOH repair requirements, and the SURFPAC and SURFLANT type commander routine repair items normally scheduled for accomplishment during ROH. In all these documents, the routine overhaul of six of a ship's six main feed pump turbines is specified. However, this analysis has shown that, except for the steam admission valve and servomotor, the Terry turbine has operated reliably throughout the data period. It is concluded, therefore, that the routine overhaul of all six main feed pump turbines is not justified. Each turbine should be subjected to a POT&I before BOH and ROH, and should be repaired on the basis of the POT&I results and each ship's CSMP. If an overhaul is determined to be required, it should be accomplished in accordance with TRS 0255-086-653. The turbines should be maintained during the operating cycle by ship's force, with IMA assistance provided as required, by using a run-to-failure maintenance strategy.

It has been shown that a substantial amount of maintenance has been required to correct steam admission valve and servomotor failures, that those failures have caused degradation of ships' primary missions, and that steam admission valve and servomotor failures are likely to occur during an extended operating cycle. Therefore, the steam admission valves and servomotors should be overhauled during BOH. Steam admission valve and servomotor repairs should be accomplished during ROH on the basis of the inspection defined by MRC F-13 U-5, the POT&I of the entire turbine, and each ship's CSMP.

Recommendations. The following actions are recommended:

- Include in the CG-26 CMP a qualified task for a depot activity to repair the main feed pump turbines during ROH on the basis of the POT&I results and each ship's CSMP. If a turbine overhaul is determined to be required, the overhaul should be accomplished in accordance with TRS 0255-086-653.

- Overhaul the Terry main feed pump turbine steam admission valves and servomotors to class B standards during BOH. Repair the valves and servomotors during ROH as shown to be necessary by the inspection defined by MRC F-13 U-5, the POT&I of the entire turbine, and each ship's CSMP, and include these repairs as a qualified task in the CG-16 and CG-26 CMPs for depot accomplishment.

- Delete the requirements for routine overhaul of all six main feed pump turbines during BOH from the CG-26 Class DDEOC BOH repair requirements.

- Add MRCs F-13 Q-20 and F-13 U-5 (inspections and tests of the steam admission valve) to MIP F-13/84-77.

- Maintain the Terry main feed pump turbines during the operating cycle by using a run-to-failure maintenance strategy. Corrective maintenance should be accomplished by ship's force, and IMA assistance should be provided as required.

3.8.2.3 Main Feed Booster Pumps

Background

Each CG-16 and CG-26 Class ship has six Buffalo Pumps Division, Buffalo Forge Company main feed booster pumps installed to provide hot boiler feed-water to the suction side of the main feed pump from the deaerating feed heater tanks (DFTs). They are supported by APL 016150378 and are rated at 490 gpm at 65 psi. Two of the six pumps mounted on the CG-16 Class ships are turbine-driven; the other four are motor-driven. All of the CG-26 Class pumps are motor-driven.

MDS Summary

A summary of the MDS data reported against the main feed booster pump is presented in table 3-22. On an aggregate basis, the main feed booster pumps had a reported burden of 955 JCNs, 10,301 ship's force man-hours, and 9,202 IMA man-hours, for a total of 19,503 man-hours, or about 29 man-hours per pump per operating year. From the MDS narrative review it was determined that a majority of this burden (11,995 man-hours or about 62 percent) was the result of significant repairs; i.e., replacement or repair of the major wearing parts. Of the man-hour burden associated with the significant repairs, ship's force reported 6,196 man-hours (52 percent of the significant repair total) and IMAs reported 5,799 man-hours (48 percent of the significant repair total). Thus the repair capability for this pump is about evenly divided between ship's force and IMAs. The 285 significant repairs averaged about 42 man-hours, (about two and one-half days if two men each worked eight hours per day) (and averaged about 2.4 pump-years between repairs). Thus repair or replacement of major wearing parts can be expected during an extended operating cycle.

Parts-Usage Summary

In addition to the repetitive usage of consumable pump parts such as packing, gaskets, and fasteners, there was also repetitive usage of the major wearing pump parts such as shaft sleeves, bushings, ball bearings, and wearing rings. This usage averaged about 96 percent of the part population (0.85 percent of the part population per ship per operating year), which further substantiates the conclusion that repair or replacement of the major wearing pump parts can be expected during a 60-month operating cycle.

CASREP Summary

A total of 12 CASREPs were submitted against the main feed booster pumps during the period 1 January 1976 through 31 August 1978, which is a submission rate of one CASREP every 25 pump-years. All of the CASREPs had a severity code of C-2, which indicates limited degradation of primary ship mission areas. Seven CASREPs were submitted for excessive clearances or wear, four CASREPs for bearing failure or a frozen pump, and one CASREP for a coupling failure. Therefore, failures of the main feed booster pumps

have not been repetitive and have resulted in only limited degradation of ships' primary missions. Downtime for these failures totaled 6,611 hours (275 days) for an average of 551 hours (46 days) per CASREP. Downtime awaiting supply totaled only 1,164 hours (49 days) in two CASREPs. None of the other 10 CASREPs reported any downtime awaiting supply. Thus about 82 percent of the downtime (5,447 hours) was reported for awaiting maintenance. It is concluded, on the basis of these data, that the significance of main feed booster pump failures is low, that degradation of ships' missions resulting from main feed booster pump failure is limited, and that failures will occur infrequently during a 60-month operating cycle. In addition, the redundant installations of main feed booster pumps reduces the impact of main feed booster pump downtime on ships' missions.

PMS Summary

There are three MIPs that define the planned maintenance requirements for the main feed booster pumps. Table 3-26 presents the hull-to-MIP applicability.

Table 3-26. MAIN FEED BOOSTER PUMP HULL-TO-MIP APPLICABILITY

MIP	Hulls Applicable
F-14/21-58	CG-16,-17,-18,-19,-20,-21,-22,-23,-24, -29,-30,-31,-33
F-14/30-67*	CG-16,-17,-18,-19,-20,-21,-22,-23,-24
F-14/80-58	CG-27,-28,-32,-34

*Also includes turbines.

Although the MIP numbers are different, the maintenance specified is the same for all three MIPs. These comprehensive MIPs specify some condition assessment procedures, such as a sound test of the ball bearings, in addition to the more usual visual inspections and measurements of pump clearances.

There is a requirement listed on each MIP to inspect pump internal parts each cycle during shipyard overhaul. On MIPs F-14/21-58 and F-14/30-67 this requirement is MRC F-14 C-1; on MIP F-14/80-58 it is MRC F-14 U-16. However, these MRCs are identical in procedure and requirements. Because all of these MRCs are normally scheduled for accomplishment during shipyard overhauls, they normally would not be scheduled during the operating cycle. However, the MRCs can be used as troubleshooting tools to assist ship's forces and IMAs to define specific repairs when there is some main feed booster pump performance degradation indicated, because the wearing ring and bearing clearances specifications are contained in the MRC. The MRCs should also be used to define any necessary repairs resulting from wear to be accomplished during ROH.

ROH Repair History and DDEOC BOH Repair Requirements

There is a difference between classes in the maintenance historically performed on the main feed booster pumps during ROHs. It was reported in the CG-16 Class repair profile that four of five SARPs specified overhaul of two of six pumps, while the CG-26 Class repair profile reported that three of five SARPs specified overhaul of six of six pumps. Overhaul of six of six main feed booster pumps is considered to be a SURFPAC routine item. Both the CG-16 and CG-26 Class DDEOC BOH repair requirements specify that six of six main feed booster pumps should be overhauled in accordance with the TRS during BOH.

Although major main feed booster pump failures and repairs are likely to occur during an extended operating cycle, the significance of pump failure is low and ships' forces and IMAs can make repairs in about two and one-half days. Because the average time between significant repairs was shorter than the periodicity of the cyclic PMS inspection, the pumps have effectively been maintained according to a run-to-failure maintenance strategy. Use of this strategy has resulted in few CASREPs, or infrequent and limited degradation of ships' primary missions. It is concluded that routinely overhauling main feed booster pumps during BOH and ROH is not justified by the maintenance data. Therefore, the main feed booster pumps should be subjected to a POT&I before BOH and ROH, and should be repaired by ship's forces or IMAs on the basis of the POT&I results, the PMS internal parts inspection, and each ship's CSMP. Degradation and wear, which are likely to occur, may necessitate pump overhaul, as determined by the POT&I results, the PMS inspection, and each ship's CSMP. If required, an overhaul should be accomplished by a depot activity in accordance with TRS 0255-086-647. During the operating cycle, the pumps can continue to be maintained by ship's forces and IMAs by using a run-to-failure maintenar.ce strategy.

Recommendations

The following recommendations are made:

- Include in the CG-16 and CG-26 CMPs qualified tasks for ship's force and IMA to repair the main feed booster pumps during ROH on the basis of the POT&I results, the PMS inspection, and each ship's CSMP. The POT&I results, PMS inspection results, and the CSMP may indicate some overhauls are required. When necessary, overhaul of main feed booster pumps should be performed by a depot activity in accordance with TRS 0255-086-647. Make repairs on the same basis during BOH.
- Delete the requirement for routine overhaul of six of a ship's six main feed booster pumps from the CG-16 and CG-26 Class DDEOC BOH repair requirements.
- Maintain the main feed booster pumps during the operating cycle by using a run-to-failure maintenance strategy, with the necessary repairs performed by ship's force and IMA personnel.

3.8.2.4 Main Feed Booster Pump Turbines (CG-16 Class only)

Background

Two of the six main feed booster pumps installed on each CG-16 Class ship are driven by a Terry Corporation type YW-3 steam turbine supported by APL 057700082. None of the CG-26 Class main feed booster pumps is turbine driven.

MDS Summary

A summary of the MDS data reported against this turbine is presented in table 3-22. An overhaul of one turbine accounted for 1,179 man-hours (46 percent) of the total man-hours reported. Discounting this repair as unusual because it was the only turbine overhaul reported, the resulting turbine man-hour burden totaled 1,392 man-hours, which is an average of 14.8 man-hours per turbine per operating year. Of this total, 780 man-hours (56 percent of total man-hours) were reported for significant repairs -- repairs that required lifting the casing, replacing the carbon packing, repairing the steam admission valve, etc. The remainder of the man-hour burden, 612 man-hours (44 percent of total man-hours), was reported for PMS deferrals and nonrepetitive repairs.

Each of the 35 significant repairs (including the overhaul) required an average of 56 man-hours to complete, which is about three and one-half days if two men work eight hours per day. The mean time between these significant repairs was about three turbine-years per repair. Excluding the one turbine overhaul reported, the average man-hour burden per significant repair was 23 man-hours. The repair capability for this turbine rests primarily with ship's forces, as they reported 92 percent (714 man-hours) of the man-hours reported for all of the significant repairs except the turbine overhaul. From these data it is concluded that ship's forces are likely to be required to make some significant main feed booster pump turbine repairs during a 60-month operating cycle.

Parts-Usage Summary

Parts usage for all turbine parts, including consumables, was nonrepetitive -- in marked contrast to the DDG-37 Class main feed booster pump turbines, which experienced high bearing usage. No such usage was identified for the CG-16 Class turbines, primarily because the turbine reduction gear is simpler than the reduction gear used in the DDG-37 Class turbines. On the basis of these data, it is concluded that while some part replacements may occur during a 60-month extended operating cycle, the specific parts and replacement intervals cannot be predicted.

CASREP Summary

There were no CASREPs reported against the main feed booster pump turbines during the period 1 January 1976 through 31 August 1978, although many major repairs were reported in the MDS to correct turbine failures. On the basis of this data, it is concluded that main feed booster pump

turbine failures have in no way degraded ships' primary missions; therefore, the significance of main feed booster pump turbine failure is low.

PMS Summary

The main feed booster pump turbines are maintained according to MIP F-14/30-67. This comprehensive MIP specifies minor periodic repairs, to include lubrications and cleanings, inspections, and condition assessment tests such as clearance measurements and temperature monitoring. Several of the requirements are to be accomplished during shipyard overhaul; these requirements include inspections of the turbine exterior, carbon packing, and reduction gears; measurements of the journal bearing clearances, and tests of the relief valve. On the basis of the MDS repair history and CASREP data it is judged that the requirements specified on the MIP are adequate to maintain the main feed booster pump turbines during a 60-month operating cycle.

ROH Repair History and DDEOC BOH Repair Requirements

Overhaul of two of six main feed booster pumps and drivers is reported in the CG-16 Class repair profile as appearing in four of five SARPs reviewed. Specific turbine ROH repair history is not listed in the repair profile. A review of five CG-16 Class SARPs (see table 3-27 for a list of SARPs by hull and year of overhaul) showed that in each overhaul, both main feed booster pump turbines were overhauled to class B standards. The CG-16 Class DDEOC BOH repair requirements specify overhaul of both main feed booster pump turbines in accordance with the TRS.

Table 3-27. SARPS REVIEWED BY HULL AND YEAR OF SHIP OVERHAUL

Hull	Year of Overhaul
CG-16	1977
CG-21	1973
	1978
CG-22	1975
CG-23	1977

This analysis has shown that while failures have occurred and significant repairs of the main feed booster pump turbines have been accomplished, the failures have not caused degradation of ships' primary missions. In addition, ship's forces have been shown to be capable of making the majority of turbine repairs (except overhaul) within four days, with minimal assistance from IMAs. Therefore, it is concluded the routine overhaul of both main feed booster pump turbines during BOH and ROH is not justified. Further, a run-to-failure maintenance strategy is appropriate for the turbine during a 60-month operating cycle. Turbines should be repaired during BOH and ROH on the basis of POT&I and PMS inspection results and each ship's CSMP. If a turbine overhaul is determined to be necessary, it should be accomplished in accordance with a TRS. Turbines should be repaired during the operating cycle by ship's force, with IMA assistance provided when necessary.

Recommendations

The following actions are recommended:

- Include a qualified task in the CG-16 CMP to have a depot activity repair the turbines during ROH on the basis of the POT&I test and PMS inspection results and each ship's CSMP. If a turbine overhaul is determined necessary, a depot activity should repair the turbines in accordance with TRS 0255-086-649. Make repairs on the same basis during BOH.
- Delete the requirement for routine overhaul of both main feed booster pump turbines from the CG-16 Class DDEOC BOH repair requirements.
- Maintain the main feed booster pump turbines during the intracycle by using a run-to-failure maintenance strategy. Ship's forces should repair the turbines, and IMA assistance should be provided as necessary.

3.8.2.5 Reserve Feed Transfer Pumps and Vacuum Priming Pumps

Background

The reserve feed transfer pumps are used primarily to transfer reserve feedwater from tanks in one fireroom to tanks in the other fireroom. Hulls CG-16 through -24, -26, -27, -28, -32, and -34 have Weil Pump Company model NRULA1341 centrifugal pumps installed. The pumps are supported by APL 016060107 and are identical to the reserve feed transfer pumps installed on DDG-37 Class ships. Hulls CG-29, -30, -31, and -33 have Carver Pump Company type N, model 17C-1 centrifugal reserve feed transfer pumps supported by APL 017030107.

The vacuum priming pumps maintain the prime of the reserve feed transfer pumps by exhausting the air entrapped in the reserve feed transfer pump and its suction line. Two APLs, 017070056 and 017070072, support the Nash Engineering Company type MD 572 pumps. Although supported by different APLS, the pumps installed on the CG-16 and CG-26 Classes are identical.

Both the reserve feed transfer pumps and vacuum priming pumps are close-coupled to the same driving motor and are installed on a common foundation.

Vacuum Priming Pump Maintenance History

Although the vacuum priming pumps (APLs 017070056 and 017070072) were included in the CG-16 and CG-26 Classes' selected items for analysis lists as items that required detailed analysis, there was only a small maintenance burden reported. No repetitive failures or part replacements occurred; this fact led to the conclusion that the pumps operated reliably during the data period. Because no CASREPs were submitted, it is concluded that the failures that did occur did not degrade ship missions. Because of the redundant installations of these pumps, the maintenance necessary to repair

or replace worn parts can be deferred until sufficient time and facilities are available. Therefore, the vacuum priming pumps should be repaired by ship's force or an IMA during BOH and ROH on the basis of POT&I results and each ship's CSMP.

Reserve Feed Transfer Pump MDS Summary

A summary of the MDS data reported against the reserve feed transfer pumps is presented in table 3-22. From the data in this table it can be seen that the man-hour burdens reported against the pump APLs were similar. On an aggregate basis (summing the CG-16 and CG-26 Class data), APL 016060107 had a burden of 83 JCNs and 2,026 man-hours (1,590 man-hours reported by ships' forces and 436 man-hours reported by IMA). The man-hour burden averaged 13.0 man-hours per pump per operating year, which compares closely with the average burden reported for APL 017030107, which was 13.3 man-hours per pump per operating year. A review of the MDS narratives determined that a majority of the man-hours for each APL were reported for replacement of major wearing parts; i.e., for the previously defined significant repairs. The burdens for the significant repairs totaled 1,799 man-hours (89 percent of the APL total) for the 33 significant repairs reported against APL 016060107 and 758 man-hours (92 percent of the APL total) for the 15 significant repairs reported against APL 017030107. On the average, APL 016060107 required a significant repair every 4.7 pump-years and APL 017030107 required a significant repair every 3.6 pump-years. Each significant repair required an average of about 54 man-hours for APL 016060107 and 51 man-hours for APL 017030107. Thus these repairs can be accomplished within four days if two men each worked eight hours per day. Both ship's force and IMA have demonstrated a repair capability for the pumps. These data lead to the conclusion that some reserve feed transfer pump repairs will be required during an extended operating cycle, and that ship's force and IMA can make the repairs required within a few days.

Reserve Feed Transfer Pump Parts-Usage Summary

As stated above, a majority of the man-hours for the reserve feed transfer pumps were reported for replacement of major wearing parts. These parts included casing and impeller wearing rings and shaft sleeves. The repetitive usage of these parts (see table 3-28) confirmed the results of the MDS narrative analysis, which showed that major repairs would be likely during the intracycle. On the basis of these data, it is concluded that replacement of the major wearing pump parts is likely for both APLs during a 60-month operating cycle.

Reserve Feed Transfer Pump CASREP Summary

Only one CASREP was submitted against the reserve feed transfer pumps during the period 1 January 1976 through 31 August 1978, although there were many repairs reported in the MDS for failures requiring replacement of wearing parts. Failures that degrade ship missions have thus not been repetitive, and are not likely to be repetitive during an extended operating cycle. Therefore, it is concluded that the significance of reserve feed transfer pump failure is low.

Table 3-28. RESERVE FEED TRANSFER PUMP PARTS — USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
APL 016060107						
9C-4320-00-393-3486	Shaft sleeve	1	28	24	86	9
9C-4320-00-541-8885	Casing wearing ring	2	56	38	68	11
9C-4320-00-541-8886	Impeller wearing ring	2	56	39	70	12
APL 017030107						
9Z-3120-00-013-7326	Sleeve bushing	1	8	8	100	3
9C-4320-00-393-3486	Shaft sleeve	1	8	7	88	2
9C-4320-00-759-3904	Lantern ring	1	8	8	100	2
9C-4320-00-989-7698	Casing wearing ring	2	16	13	81	2

Reserve Feed Transfer Pump PMS Summary

Two MIPs define the planned maintenance for the reserve feed transfer pumps. MIP A-40/236-15 applies to APL 016060107, and MIP A-40/106-68 applies to APL 017030107. These MIPs include requirements to inspect the packing gland adjustment, the foundation fasteners, and the internal pump parts, as well as a requirement to renew packing on the basis of the gland adjustment inspection. These MIPs are thus comprehensive and are considered adequate to maintain the pumps during an extended operating cycle.

Reserve Feed Transfer Pump ROH Repair History and DDEOC BOH Repair Requirements

There were no repetitive repairs of reserve feed transfer pumps accomplished during ROHs, according to both the CG-16 and CG-26 Class repair profiles. Overhaul of the pumps during BOH in accordance with the TRS is specified by the CG-26 Class DDEOC repair requirements for BOH, while the similar CG-16 Class document specifies testing in accordance with the 1200 psi test and certification procedure. Considering that repetitive pump repairs have not been accomplished during ROHs, the requirement to routinely overhaul the pumps during BOH in accordance with the TRS is judged to be unwarranted. Recognizing ship's force and IMA repair capabilities and the limited degradation that failures have caused, repairing the pumps on the basis of POT&I results, as specified by the CG-16 Class DDEOC BOH repair requirements and each ship's CSMP, appears to be more appropriate. Therefore, the reserve feed transfer pumps should be repaired during BOH and ROH on the basis of the POT&I results and each ship's CSMP.

Recommendations

The following recommendations are made:

- Include a qualified task in the CG-16 and CG-26 CMPs for ship's force, with IMA assistance, to repair the reserve feed transfer pumps during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs on the same basis during BOH.
- Delete the CG-26 DDEOC BOH repair requirement to routinely overhaul the reserve feed transfer pump.
- Maintain the reserve feed transfer pumps during the operating cycle by using a run-to-failure maintenance strategy.

3.8.2.6 Feed Subsystem Pump Motors

Background

The CG-16 and CG-26 Class selected items for analysis lists identified the main feed booster pump motors and the reserve feed transfer pump motors as equipments requiring detailed analysis. These motors are supported by four APLs, which are listed (with the applicable motor and class) in table 3-29.

Table 3-29. CONFIGURATION OF FEED SUBSYSTEM MOTOR BY APPLICATION, CLASS, AND APL			
Motor Application	Class	APL	Quantity Installed
Main feed booster pump	16	174750518	36
	26	174802352	54
Reserve feed transfer pump	16	174750602	18
	26	174750602	10
	26	174802580	8

MDS Summary

The summary of the MDS burden data presented in table 3-22 shows that the average reserve feed transfer pump motor burdens were less than two man-hours per motor per operating year. This burden is judged to be negligible, and leads to the conclusion that the motors operated reliably throughout the data period. Continued use of the existing run-to-failure maintenance strategy is recommended.

A similar maintenance strategy is also indicated for APL 174750518, the CG-16 Class main feed booster pump motor. Its reported man-hour burden averaged only 2.3 man-hours per motor per operating year, again leading to the conclusion that the pump motor operated reliably throughout the data period.

CG-16 Class ships have two turbine-driven main feed booster pumps that are normally used more than the motor-driven pumps. CG-26 Class ships have only motor-driven pumps. Therefore, a higher maintenance burden would be expected for the CG-26 Class pump motors than for the CG-16 Class pump motors; from the data presented in table 3-22, it can be seen that this is the case. An average of about nine man-hours per motor per operating year were experienced by the CG-26 Class motor (APL 174802352), which is about seven man-hours per motor per operating year higher than the CG-16 Class pump (APL 174750518). A review of the MDS narratives determined that 53 significant repairs -- that is, of shorted or open windings, bearing replacements, or overhaul -- were reported with a mean time between significant repairs of about six motor-years. A total of 2,707 man-hours were reported for the significant repairs, which is an average of 51 man-hours per repair. Ship's force reported 864 man-hours (32 percent of total man-hours) and IMAs reported 1,893 man-hours (68 percent of total man-hours). Therefore, IMAs have the primary capability to repair the motor, although ship's force often make repairs that do not require motor rewinding.

Parts-Usage Summary

There was no repetitive usage of reserve feed transfer pump motor parts, leading to the conclusion that similar random usage can be expected during an extended operating cycle. Conversely, there was repetitive usage

(see table 3-30) of CG-26 Class main feed booster pump motor bearings during the data period, with an average time between replacements of 67 pump-months, which indicates that bearing replacement is likely during a 60-month operating cycle.

CASREP Summary

No CASREPs were submitted against the reserve feed transfer pump motors, indicating that mission degrading failures have not occurred. Ten CASREPs were submitted against the main feed booster pump motor -- all for grounded motors -- for a CASREP submission rate of one CASREP every 33 pump-years, which is judged to be low. Therefore, CASREP submissions resulting from main feed booster pump motor failures are likely to be low during a 60-month operating cycle. Reported downtime totaled 8,270 hours (345 days), which is an average of 827 hours per CASREP (34 days). All of the downtime was reported awaiting maintenance. Because none of the downtime was reported awaiting supply, it is concluded that parts support for this pump is good. Therefore, ship's force can expect to wait up to a month before main feed booster pump motor repairs are completed whenever a motor becomes grounded. However, the CASREP submission rate indicates that grounding failures are infrequent and few are likely to occur during a 60-month operating cycle. On the basis of the low CASREP submission rate and the redundant pump and motor installation, it is concluded that the significance of main feed booster pump motor failure is low.

PMS Summary

All motors are maintained according to the requirements of MIP EL-4/28-88, which is a general MIP applicable to all AC and DC motors. The cleaning and inspection requirements included on this MIP are adequate to maintain those motors during a 60-month operating cycle.

ROH Repair History and DDEOC BOH Repair Requirements

No repetitive repairs were reported for the reserve feed transfer pump motors in the repair profiles or in the CG-16 Class DDEOC BOH repair requirements. The CG-26 Class DDEOC BOH repair requirements specify routine overhaul of the motors in accordance with the TRS. This analysis has shown that there has been a low burden, no CASREP submissions, and negligible parts usage for this motor, leading to the conclusion that routine overhaul is not required. During BOH and ROH, therefore, reserve feed transfer pump motors should be repaired on the basis of POT&I results and each ship's CSMP.

Repetitive repairs of main feed booster pump motors were specified in both repair profiles. The CG-16 Class repair profile reported that class B overhauls of two of six main feed booster pumps and drivers were specified in four of five SARPs; the CG-26 Class repair profile reported that class B overhauls of six of six main feed booster pumps and motors were specified in three of five SARPs. Routine overhaul of all main feed booster pump motors is specified in the CG-16 and CG-26 Class DDEOC BOH repair requirements. Although some major motor repairs were required during the data

Table 3-30. CG-26 CLASS MAIN FEED BOOSTER PUMP MOTOR (APL 174802352) PARTS — USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
9Z-3110-00-155-6266 9Z-3110-00-155-6298	Shaft bearings	2	108	65	60	--

period, the low average man-hour burden and the low CASREP submission rate indicate that failures have not significantly degraded ships' missions and that the man-hours required to correct those failures have not been a sizable burden. Therefore, the routine overhaul of all main feed booster pump motors is not warranted, and the practice should be discontinued. Main feed booster pump motors should be repaired during BOH and ROH on the basis of POT&I results and each ship's CSMP.

Recommendations

The following actions are recommended:

- Include a qualified task to have a depot activity repair the reserve feed transfer pump motors and main feed booster pump motors during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.
- Delete the routine overhaul of main feed booster pump motors from the CG-16 and CG-26 Class DDEOC BOH repair requirements.

3.8.2.7 Deaerating Feed Heater Tanks

Background

Two deaerating feed heater tanks (DFTs) are installed on each CG-16 and CG-26 Class ship, one per fireroom. Each DFT heats and deaerates condensate and stores the resulting feedwater for use in the main boilers. The DFTs installed in both classes are the same and are supported by APLs 074160051 and 074160052. They were manufactured by the Cochran Division of the Crane Company and have a capacity of 293,000 pounds per hour.

MDS Summary

A summary of the maintenance burden data reported against the DFTs is presented in table 3-22. The combined man-hour burdens reported against the DFTs averaged about 25 man-hours per DFT per operating year, which is similar to the 24 man-hours per DFT per operating year reported against the DDG-37 Class DFT; this similarity is expected because of the design and operational similarities between the two classes' DFTs. A substantial number (2,156 man-hours, or about 38 percent) of the man-hours were reported for completion of deferred PMS. Only one repetitive failure, a collapsed bulkhead or cracked DFT shell, was reported in the data, and that failure accounted for a total of 14 JCNs and 1,083 man-hours (19 percent of total man-hours). The remainder of the man-hours were reported for nonrepetitive repairs.

The Navy has recognized that shell buckling has been a problem to the CG-16 and CG-26 Classes and has addressed the problem in two ways. First, advisory 21 of the Steam Propulsion Improvement Project was developed to provide guidance to ship personnel on DFT operations and was supplied to all ships with 1,200 psi propulsion plants. Second, shipalts have been

prepared for both classes to reinforce the DFTs to prevent shell buckling and other structural damage. Shipalts CG-16-1213D and CG-26-393D are identical and have been installed on five and six ships, respectively. These shipalts should be accomplished on the remaining ships of each class not later than BOH to prevent DFT structural damage.

Parts-Usage Summary

DFT parts usage was repetitive for only two parts -- a glass tube and a helical compression spring. Usage of these parts was reported by 15 and 12 ships, respectively, indicating that most but not all of the ships have replaced these parts. About 81 percent of the glass tube maintenance actions were part-only JCNs in which no man-hours were reported, and in which the reason for the part replacement could not be identified. About 40 percent of the maintenance actions reporting spring replacement were also part-only JCNs. However, for the remainder of the spring replacements, narrative data indicated that replacement of the springs occurred primarily during PMS, with some replacements occurring during DFT nozzle overhauls. Although replacement of these parts is likely during a 60-month operating cycle, replacement appears to be primarily the result of preventive maintenance rather than failures. Replacement of the springs is within ship's force capability and should result in little DFT downtime.

CASREP Summary

There were no CASREPs submitted against the DFTs in either class during the CASREP data period, indicating that mission degrading DFT failures have not occurred. Therefore, it is concluded that mission degrading DFT failures are not likely to occur during a 60-month operating cycle.

PMS Summary

The DFTs are maintained according to MIP F-27/35-57, which is comprehensive in specifying maintenance on the valves and internal parts. A series of cyclic periodicity requirements to clean and inspect, test, or adjust valves or the internal parts should assure reliable DFT operation during an extended operating cycle.

ROH Repair History and DDEOC Repair Requirement

There were no repetitive repairs reported in either the CG-16 Class or the CG-26 Class repair profiles. The CG-16 Class and CG-26 Class DDEOC BOH repair requirements specify tests of the DFTs in accordance with the 1200 psi Steam Propulsion Plant Test and Certification Manual; i.e., perform a POT&I of each DFT. Except for the shell buckling failures, the DFTs have operated reliably and have required only replacements of some minor parts to maintain operation. In addition, the cyclic PMS requirements should identify any other deficiencies in DFT condition (except for structural damage) that should be repaired during BOH and ROH. Therefore, each DFT should be subjected to a POT&I before BOH and ROH and should be repaired on the basis of the POT&I results and each ship's CSMP.

Recommendations

The following actions are recommended:

- Include a qualified task in the CG-16 and CG-26 CMPs to have a depot activity repair the DFTs during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.
- Accomplish the DFT strengthening shipalts (shipalts CG-16-1213D and CG-26-393D) not later than BOH on those ships not already modified.

3.8.3 Condensate Subsystem

3.8.3.1 Main Condensate Pumps

Background

Four main condensate pumps are installed on each CG-16 and CG-26 Class ship. Two pumps on each CG-16 Class ship are turbine-driven, and the other two are motor-driven. All four pumps installed on each CG-26 Class ship are motor-driven. The pumps installed in both classes (supported by APL 016150379) are identical and are manufactured by the Buffalo Pump Division of the Buffalo Forge Company.

MDS Summary

A summary of the MDS data reported against the main condensate pumps is presented in table 3-23. On an aggregate basis, the main condensate pumps had a reported burden of 575 JCNs, 7,234 ship's force man-hours, and 6,323 IMA man-hours, for a total of 13,557 man-hours, or about 30 man-hours per pump per operating year. A review of the MDS narratives determined that a substantial majority of the man-hours (10,870 man-hours or about 80 percent of total man-hours) were reported for significant repairs*. Ship's force reported 6,186 man-hours (57 percent of total man-hours) and IMAs reported 4,684 man-hours (43 percent of total man-hours), indicating that the primary repair capability lies with ship's force, although some major repairs were accomplished by IMAs. The 225 significant repairs averaged about 48 man-hours per repair, or about three days if two men each worked eight hours per day, and were repetitive. The mean time between these significant repairs was calculated to be about 24 months. Thus significant main condensate pump repairs can be expected during an extended operating cycle. Ship's force confirmed during discussions that major repairs occur approximately every two years, which substantiates the conclusion that some significant repairs can be expected during an extended operating cycle.

*See section 3.8.2.1 for a definition of a significant repair.

Parts-Usage Summary

In addition to the repetitive usage of consumables such as packing and gaskets, there was repetitive usage of wearing rings, shaft sleeves, bearings, and bushings (see table 3-31). These data further substantiate the conclusion that major pump repairs are likely to be required during an extended operating cycle.

CASREP Summary

A total of four CASREPs were submitted against main condensate pumps during the period 1 January 1976 through 31 August 1978, which corresponds to a submission rate of one CASREP every 50 pump-years. Two of the CASREPs reported excessive clearances, one reported impeller damage, and one reported casing erosion. All four CASREPs had a reported severity of C-2, which indicates that only minor degradation of primary ship missions occurred. Downtime totaled 2,376 hours (99 days), or about 594 hours (25 days) per CASREP. All of the downtime was reported awaiting maintenance, which indicates that parts support is adequate and has not resulted in mission degradation. These data lead to the conclusions that degradation of ships' primary missions is not likely to occur as a result of main condensate pump failure, and that when failures do occur, parts support is adequate and will not normally inhibit pump repairs.

PMS Summary

There are three MIPs that define the planned maintenance requirements for the main condensate pump. Table 3-32 presents the hull-to-MIP applicability. The MRCs on these MIPs are nearly identical in their maintenance. One difference is that the first two MIPs list a cyclic requirement to inspect pump internal parts while a similar requirement on the third MIP is unscheduled, but is to be performed during shipyard overhaul. In all other respects, the MIPs are similar, requiring inspections and tests to determine pump condition.

The MRCs that specify internal parts inspection are supposed to be scheduled for accomplishment during shipyard overhaul and thus are seldom scheduled during the operating cycle. However, they can be used to assist ship's force and IMA to define necessary repairs when main condensate pump performance degradation is indicated.

ROH Repair History and DDEOC BOH Repair Requirements

There were no routine repairs recommended by either the CG-16 Class or CG-26 Class repair profiles. Both the CG-16 Class and CG-26 Class DDEOC BOH repair requirements specify routine overhaul of the pumps in accordance with the TRS. However, this analysis has shown that although significant repairs are likely to be required during an extended operating cycle, the repairs are within ship's force capability (with some IMA assistance), and the associated failures have resulted in infrequent and minor degradation

Table 3-31. MAIN CONDENSATE PUMP (APL 016150379) PARTS — USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
9Z-3120-00-098-1747	Throat bearing	1	72	106	147	17
9Z-3120-00-098-1749	Sleeve bearing	1	72	156	217	17
9C-4320-00-098-1757	Casing wearing ring	2	144	226	157	18
9Z-3110-00-156-8064	Ball bearing	1 pr.	72 pr.	131 pr.	182	17
9C-4320-00-288-8961	Impeller wearing ring	2	144	227	158	17
9Z-3120-00-585-9565	Sleeve bushing	1	72	137	190	18
9C-4320-00-627-0492	Shaft sleeve	1	72	116	161	17
9C-4320-00-627-0493	Shaft sleeve	1	72	117	162	17
9C-4320-00-767-5596	Impeller wearing ring	2	144	223	155	18
9C-4320-00-767-5597	Casing wearing ring	1	72	149	207	18
9C-4320-00-767-5598	Casing wearing ring	1	72	135	188	18

Table 3-32. MAIN CONDENSATE PUMP HULL-TO-MIP APPLICABILITY	
MIP	Hulls Applicable
E-6/9-A6*	CG-16,-17,-18,-19,-20,-21,-22,-23, and -24
E-6/53-A6	CG-16,-17,-18,-19,-20,-21,-22,-23, -24,-29,-30,-31, and -33
E-6/151-B7	CG-27,-28,-32, and -34
*Also includes turbine.	

of primary ship missions. Therefore, the routine overhaul of the main condensate pumps does not appear justified. Main condensate pumps should be repaired during BOH and ROH on the basis of the POT&I results and each ship's CSMP. They should be maintained according to a run-to-failure maintenance strategy by ship's force. Repairs should be accomplished by ship's force, with IMA assistance provided as necessary.

Recommendations

The following recommendations are made:

- Include a task in the CG-16 and CG-26 Class CMPs for a depot activity to repair the main condensate pumps during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.
- Delete the routine overhauls of main condensate pumps from the CG-16 and CG-26 DDEOC BOH repair requirements.

3.8.3.2 Main Condensate Pump Turbines (CG-16 Class only)

Background

Two of the four main condensate pumps installed on CG-16 Class ships are driven by a Terry Corporation type YW-3 steam turbine, supported by APL 057700081. None of the CG-26 Class main condensate pumps is turbine-driven; therefore this discussion pertains only to CG-16 Class ships.

MDS Summary

A summary of the MDS data reported against this turbine is presented in table 3-23. A total of 1,137 man-hours (or 64 percent of the total of 1,780 man-hours) was reported for repetitive significant repairs -- repairs that required lifting the casing, replacing the carbon packing, repairing the steam admission valve, replacing or repairing bearings and shafts, etc. About 83 percent of the man-hours (948 man-hours) reported for these significant repairs were reported as having been accomplished

by ship's force, which indicates adequate ship's force repair capability. An average of about 30 man-hours was required to complete each of these 38 significant repairs. The mean time between these significant repairs was calculated to be about 33 turbine-months per repair, or much less than the 60-month operating cycle. Thus while the MDS data indicate that repetitive significant repairs are expected during an extended operating cycle, ship's forces are capable of accomplishing a majority of the repairs when failures occur. The remainder of the man-hours (643 man-hours) were reported for PMS deferrals and nonrepetitive minor repairs that are not expected to affect availability during an extended operating cycle.

Parts-Usage Summary

Except for carbon packing, usage of all turbine parts was nonrepetitive and averaged about 34 percent of the individual part populations (0.65 percent of the part population per ship per operating year). Therefore, repetitive turbine parts usage is not likely during an extended operating cycle.

CASREP Summary

There were no CASREPs submitted against the main condensate pump turbines during the period 1 January 1976 through 31 August 1978. On the basis of this data, it is concluded that main condensate pump turbine failures have not degraded ships' primary missions and, therefore, that the significance of main condensate pump turbine failure is low.

PMS Summary

The main condensate pump turbines are maintained according to MIP E-6/8-A6, which is comprehensive and which specifies a number of condition assessment requirements. These requirements include testing the speed-limiting governor, measuring thrust clearances, and sampling and inspecting the lube oil. The MDS and CASREP data indicate that the MIP requirements have been effective in maintaining reliable main condensate pump turbine operations in the past; these requirements are expected to be effective during an extended operating cycle.

ROH Repair History and DDEOC BOH Repair Requirements

Overhaul of two main condensate pump drivers (motor or turbine) is reported in the CG-16 Class repair profile as appearing in five of five SARPs reviewed. It was not possible to determine from the repair profile if the turbines were routinely overhauled during ROHs. Therefore, six CG-16 Class SARPs were reviewed to identify the repairs accomplished during ROHs. Table 3-33 presents a list of the hulls for which SARPs were reviewed and the year of overhaul of the listed ships.

Table 3-33. SARPS REVIEWED LISTED BY HULL AND YEAR OF SHIP OVERHAUL		
Hull	Year of Overhaul	Repair Accomplished
CG-16	1977	Class B (2 of 2)
CG-20	1977	Class B (2 of 2)
CG-21	1973	Class C (2 of 2)
	1978	Class B (2 of 2)
CG-22	1975	Class C (2 of 2)
CG-23	1977	Class B (2 of 2)

Thus a majority (four of six, or 67 percent) of ship overhauls included class B overhauls of both main condensate pump turbines. In addition, the CG-16 Class DDEOC BOH repair requirements document specifies overhaul of both turbines in accordance with a TRS.

This analysis has shown that, while failures have occurred and significant repairs of the main condensate pump turbines have been accomplished, the failures have not resulted in significant degradation of ships' primary missions. Ship's forces have been shown to be capable of accomplishing a majority of the turbine repairs with some assistance from IMA. Therefore, it is concluded that the routine overhaul of main condensate pump turbines is not justified and, more appropriately, that turbine repairs during BOH and ROH should be made on the basis of POT&I results and each ship's CSMP. The main condensate pump turbines should be maintained according to a run-to-failure maintenance strategy during the operating cycle; repairs should normally be accomplished by ship's force, with IMA assistance provided as necessary.

Recommendations

The following actions are recommended:

- Include a qualified task in the CG-16 CMP to have a depot activity repair the main condensate pump turbines during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.
- Delete the requirement for routine overhaul of the main condensate pump turbines from the CG-16 Class DDEOC BOH repair requirements.
- Maintain the main condensate pump turbines according to a run-to-failure maintenance strategy; ship's force should make repairs, and IMA should provide assistance as necessary.

3.8.3.3 Auxiliary Condenser Condensate Pumps

Background

Each CG-16 and CG-26 Class ship has four ship's service turbogenerators (SSTGs) installed; thus each ship has four auxiliary condenser condensate

pumps installed. The configuration of these pumps (presented by APL, hull, and manufacturer) is shown in table 3-34.

Table 3-34. AUXILIARY CONDENSER CONDENSATE PUMP CONFIGURATION

APL	Manufacturer	Applicable Hulls
016000461	Allis-Chalmers	CG-17,-18,-21,-22, and -24
016150391	Buffalo Pumps	CG-16
016020978	Warren Pumps	CG-19,-20, and -23
016150465	Buffalo Pumps	CG-26 through CG-34

MDS Summary

The MDS data summary presented in table 3-23 shows that the average man-hour burden per pump per operating year for APLs 016020978, 016150391, and 016150465 was low compared to the burden for APL 016000461. These data indicate that the pumps operated reliably during the data period and that the existing maintenance strategy is effective in maintaining the pumps during an extended operating cycle. Repairs should continue to be made during ROH and during BOH on the basis of the POT&I results and each ship's CSMP. There is, therefore, no further discussion of APLs 016020978, 016150391, and 016150465 in this report. Conversely, the burden reported against APL 016000461 indicates that maintenance history data should be analyzed further.

A review of the MDS narrative transaction data showed that 43 significant repairs (38 percent of the total JCNs reported) were reported against APL 016000461, resulting in a mean time between significant repairs of about three pump-years. The man-hour burden associated with these repetitive repairs totaled 1,026 man-hours, of which ship's force reported 737 man-hours (72 percent of total man-hours) and IMAs reported 289 man-hours (28 percent of total man-hours). Because of the portion of man-hours reported by ship's force, it is concluded that ship's forces have demonstrated a capability to repair this pump. Thus significant repairs of this pump can be expected during the operating cycle, and most repairs can be expected to be accomplished by ship's force with some IMA assistance.

Parts-Usage Summary

Repetitive usage of consumable parts and major wearing pump parts was reported against APL 016000461. Usage of the major wearing parts (see table 3-35) -- such as bearings, bushings, shaft sleeves, wearing rings, etc. -- was very repetitive, which leads to the conclusion that replacement of major wearing parts is to be expected during an extended operating cycle. These data confirm the conclusion, stated above, that significant repairs are likely to be required during an extended operating cycle.

Table 3-35. AUXILIARY CONDENSER CONDENSATE PUMP (APL 016000461) PARTS – USAGE SUMMARY DATA

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (x100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature					
9Z-3120-00-106-2914	Bushing	1	20	28	140	5
9Z-3120-00-106-2915	Sleeve	1	20	37	185	5
9Z-3120-00-106-2916	Sleeve	1	20	35	175	5
9Z-3110-00-109-1349	Bearing	1 pr.	20 pr.	47 pr.	235	5
9C-4320-00-122-0606	Wearing ring	1	20	32	160	5
9C-4320-00-122-4323	Throat bushing	1	20	25	125	4
9C-4320-00-122-4324	Wearing ring	1	20	40	200	5

CASREP Summary

Two CASREPs were reported against APL 016000461 during the period 1 January 1976 through 31 August 1978, which is a submission rate of one CASREP every 25 pump-years. This submission rate is considered to be low, leading to the conclusion that the failures of auxiliary condenser condensate pumps have not degraded ships' primary missions. This conclusion is confirmed by the severity codes of C-2 reported in both CASREPs, which shows that only minor mission degradation has resulted from pump failures. Downtime totaled 2,047 hours (85 days), for an average of 1,024 hours (43 days) per CASREP. Approximately 67 percent (1,369 hours) of the downtime was reported awaiting parts, indicating that parts support has not always been adequate. The remainder of the downtime (678 hours or about 28 days) was spent awaiting maintenance. These data indicate that the significance of auxiliary condenser condensate pump failure is low and that parts support has been, at times, less than adequate. However, because of the low submission rate, mission degrading pump failures are unlikely during an extended operating cycle.

PMS Summary

MIP E-16/362-14 defines the planned maintenance for APL 016000461; this MIP should be adequate to maintain the pumps during an extended operating cycle. MIP E-16/362-14 is similar to most other pump MIPs in that it specifies inspections and some condition assessment actions, including packing, foundation fastener, flexible coupling, and internal parts inspections, and a sound test of the bearings. All of these items are requirements that define pump condition as well as any necessary maintenance. Because the internal part inspection has a cyclic periodicity, the infrequent accomplishment of the inspection will not identify intracycle repairs. Thus intracycle repairs should continue to be identified by ship's force on the basis of pump performance. Ship's forces should continue to maintain the pumps according to a run-to-failure maintenance strategy.

BOH Repair History and DDEOC BOH Repair Requirements

A review of the CG-16 Class repair profile determined that there were no repetitive repairs of auxiliary condenser condensate pumps during ROHs. Conversely, the CG-16 Class DDEOC BOH repair requirements specify routine overhaul of all four pumps during BOH. This analysis has shown that auxiliary condenser condensate pump failures have not degraded ships' primary missions, and that ship's forces have an established pump repair and maintenance capability. Therefore, it is concluded that the routine overhaul of auxiliary condenser condensate pumps is unwarranted. Pumps should be repaired during BOH and ROH on the basis of POT&I results and each ship's CSMP.

Recommendations

The following actions are recommended:

- Include a qualified task in the CG-16 and CG-26 CMPs to have ship's force repair the auxiliary condenser condensate pumps during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.
- Delete the routine overhauls from the CG-16 and CG-26 DDEOC BOH repair requirements.
- Ship's forces should continue to maintain the auxiliary condenser condensate pumps according to a run-to-failure maintenance strategy during the operating cycle.

3.8.3.4 Condensate Subsystem Pump Motors

Background

The CG-16 and CG-26 Class selected items for analysis lists identified the main condensate pump motors and the auxiliary condenser condensate pump motors as equipments requiring detailed analysis. These motors are supported by the APLs listed in table 3-36.

Table 3-36. CONFIGURATION OF CONDENSATE SUBSYSTEM MOTORS BY APPLICATION, CLASS, AND APL

Motor Application	Class	APL	Quantity Installed
Main Condensate Pump	16	174750756	18
	26	174802353	36
Auxiliary Condenser Condensate Pump	16	174750769	4
		174752156	20
		174180288	12
	26	175503457	36

MDS Summary

The MDS burden summary presented in table 3-23 shows that, except for the auxiliary condenser condensate pump motor (which is supported by APL 174750769), the man-hour burdens reported for the condensate subsystem pump motors were about five man-hours (or less) per motor per operating year. This burden is considered negligible compared to APL 174750769 and to other feed and condensate system equipments. According to the narrative data, these pump motors (except for APL 174750769) operated reliably throughout the data period with no repetitive repairs accomplished on any one motor. Therefore, continued use of the existing run-to-failure maintenance strategy is recommended for those motors. Repairs during BOH and ROH should be limited to those determined necessary by the POT&I results and each ship's CSMP. Because of the higher man-hour burden reported against APL 174750769,

a more detailed data analysis was required to determine the validity of the current maintenance strategy for that motor and to define BOH and ROH repairs.

A review of the MDS narrative transactions identified three maintenance actions (two on the same motor) that accounted for 234 man-hours or about 86 percent of the total man-hour burden reported against APL 174750769, for an average of about 78 man-hours per maintenance action. These three maintenance actions have a mean time between significant repairs of about 17 motor-years. Two of these maintenance actions were submitted to correct damage that occurred when the motors were flooded. Thus only one repair was required to correct a motor failure (which is obviously not repetitive), leading to the conclusion that repetitive failures of APL 174750769 are not likely during an extended operating cycle.

Parts-Usage Summary

There were no repetitively used parts reported against APL 174750769, leading to the conclusion that repetitive part replacements are not likely to occur during an extended operating cycle.

CASREP Summary

There were no CASREPs submitted against APL 174750769, indicating that motor failures have not degraded ships' primary missions, and that failures are not likely to degrade ships' missions during an extended operating cycle.

ROH Repair History and DDEOC BOH Repair Requirements

There were no repetitive auxiliary condenser condensate pump motor repairs reported in the CG-16 Class repair profile. However, the DDEOC BOH repair requirements specify routine overhaul of all four installed auxiliary condensate pump motors during BOH. As shown by this analysis, the auxiliary condenser condensate pumps have operated reliably throughout the data period, and are likely to continue that reliable operation during an extended operating cycle. Therefore, it is concluded that the routine overhaul of auxiliary condenser condensate pumps during BOH is not warranted and should be deleted from the DDEOC BOH repair requirements. The motors should be repaired during BOH and ROH on the basis of the POT&I results and each ship's CSMP.

Recommendations

The following actions are recommended:

- Include a qualified task in the CG-16 and CG-26 CMPs to have a depot activity repair the condensate subsystem pump motors during ROH on the basis of the POT&I results and each ship's CSMP. Make repairs during BOH on the same basis.

- Delete the routine overhauls of pump motors from the CG-16 and CG-26 Class' DDEOC BOH repair requirements.
- Continue to maintain the condensate subsystem pump motors according to a run-to-failure maintenance strategy.

3.9 SALTWATER CIRCULATING SYSTEM (SWAB 256-1)

The CG-16 and CG-26 Class saltwater circulating system supplies cooling water to the main and auxiliary condensers, main lube oil coolers, and turbogenerator lube oil and air coolers.

The main saltwater circulating system consists of two identical turbine-driven saltwater circulating pumps and two scoop injection systems, with associated valves and piping. One turbine-driven pump and one scoop injection system are associated with each main condenser. Water is provided to the main condenser and main lube oil cooler by either the scoop injection system or the pump. The scoop injection system provides cooling water at forward speeds over 12 knots. For speeds less than 12 knots and for all astern operations, cooling water is provided by the turbine-driven pump. Nonreturn or check valves prevent the reverse flow of water through these components. The turbine-driven pump has an additional damage control function in that it can, if required, apply suction to the engine room bilge and assist in removing water from the space. The condenser and lube oil cooler are both isolated from the piping by expansion joints. Associated saltwater piping and valves (including relief valves) and the turbine throttle valve constitute the remainder of the system.

Each CG-16 and CG-26 Class ship has two functionally and schematically identical auxiliary saltwater circulating systems in each engine room. Each system (a motor, close-coupled circulating pump, and motor starter) is associated with a specific turbogenerator. The motor-driven pump supplies seawater to the associated turbogenerator condenser, lube oil cooler, and generator air cooler. The water supplied to the lube oil cooler passes through an inlet duplex strainer; water to the air cooler passes through an inlet orifice. Associated piping and valves (including relief valves) constitute the remainder of the system.

The main and auxiliary saltwater circulating pumps and associated turbines and motors are the only system components that contribute significantly to the class maintenance burden. Therefore, only these components have been chosen for analysis. Because the systems are functionally identical across classes, components of the CG-16 and CG-26 Classes will be discussed together. The maintenance burdens for these selected components are shown in table 3-37.

3.9.1 Main Saltwater Circulating Pumps (APL 016020490)

Background

The main saltwater circulating pump is a vertically mounted, axial-flow pump with internal, sea water lubricated sleeve bearings, housed in

Table 3-37. MAIN AND AUXILIARY SALTWATER CIRCULATING SYSTEM MAINTENANCE BURDENS

APL	Nomenclature	Class	Applicable Ships	Total Component Population	Ship Operating Years	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Component per Operating Year
016020490	Main circulating pump 22,000 gpm	16 and 26	18	36	112.8	1,501	1,271	2,772	12.3
057950079	Main circulating pump steam turbine	16 and 26	18	36	112.8	2,902	461	3,363	14.9
016060149	Auxiliary circulating pump, 1,040 gpm	16	1	4	6.6	220	240	460	17.4
016110499	Auxiliary circulating pump, 1,120 gpm	16	8	32	45.8	2,277	2,408	4,685	25.6
016110336	Auxiliary circulating pump, 1,200 gpm	26	4	16	27.2	1,925	1,222	3,147	28.9
017030042	Auxiliary circulating pump, 1,120 gpm	26	5	20	33.2	2,547	1,697	4,244	32.0
174750859	Motor, 440 V, 15 hp, 1,755 rpm	16 and 26	6	24	39.8	476	419	895	5.6
174751861	Motor, 440 V, 15 hp, 1,750 rpm	16	8	32	45.8	208	291	499	2.7
174802516	Motor, 440 V, 15 hp, 1,719 rpm	26	4	16	27.2	107	236	343	3.2

a split casing. The pump is driven by an attached steam turbine that is driven by reduction gears rigidly attached to the pump shaft. The thrust load is carried by a thrust bearing, located in the reduction gear. The pump is manufactured by the Warren Pump Company.

The main saltwater circulating systems are identical for all ships of both classes and the analysis of these pumps has been made by regarding these ships as essentially one uniform class.

Discussion

As shown in table 3-37, the main saltwater circulating pumps have contributed an average of 12.3 man-hours per component per operating year to the combination of the organizational and IMA maintenance burden over the time period studied. There were seven CASREPs on the main circulating pumps of CG-16 and CG-26 Class ships during the period January 1972 through August 1978. Two of the casualties were caused by worn rotor bearings; ingested foreign material was reported as the cause in one CASREP; and the remaining four CASREPs were attributed to "vibration" or "metallic noises", without further identification of the specific causes. Seven CASREPs over an almost seven-year period for the combined ships of both classes is considered minimal.

Parts-usage data were reviewed but revealed no items that were used repetitively for the main circulating pumps. A review of the MDS data showed that almost no major restorative work was performed on the main circulating pump internals during the operating cycle. When a pump did fail, it was cause for a CASREP and outside assistance was required. The infrequent and unpredictable nature of casualties incurred and the general absence of corrective maintenance required during the operating cycle demonstrates the high reliability of the main saltwater circulating pumps.

The reliable performance of the main circulating pumps also indicates the adequacy of existing PMS requirements for these pumps. Maintenance index page E-5/59-28 applies to both the pump and its driving turbine (discussed in subsection 3.9.2). Neither additional requirements nor reductions in existing requirements are considered necessary.

A review of seven SARPs revealed that the main circulating pumps were scheduled to receive class B overhauls during three of the seven shipyard overhaul periods. Overhaul of the main saltwater circulating pumps is recommended in both the CG-16 and CG-26 Class repair profiles. The internals of these pumps are required to be inspected for wear once each cycle, in accordance with PMS (MIP E-5/59-28, C-1). Historically, these pumps have not been routinely overhauled at each regular overhaul period; because of this, it can be assumed that the previously noted PMS inspection often reveals the pump to be in a material condition sufficient to provide reliable service through another operating cycle. A review of the departure reports from the 1970 and 1974 shipyard overhauls of the USS WAINWRIGHT (CG-28) revealed that the main saltwater circulating pumps had been operated without overhauls for 12 years -- from the ship's commissioning in 1966

until the pumps were overhauled in 1978 at Charleston Naval Shipyard. The WAINWRIGHT's machinery division chief petty officer observed the pumps' disassembly during the 1978 yard period and stated that the propellers were found to be significantly eroded, including a "hole the size of a quarter" in one blade. But the pumps were still operating satisfactorily prior to their overhaul. NAVSEC 6153D personnel believe that if the pump internals are found to be in satisfactory condition during their cyclic inspection, they will provide reliable service through another five-year operating cycle without overhaul. On the basis of the absence of MDS data indicating significant intracycle maintenance, the operational experience of USS WAINWRIGHT, and the comments of NAVSEC 6153D personnel, it is concluded that the main saltwater circulating pumps can be expected to provide at least 10-years' reliable operation before an overhaul is required. The decision to overhaul the pumps at BOH should be made on the basis of the results of POT&I and the cyclic PMS requirement to inspect the pump internal parts.

Recommendations

As a result of this analysis, the following actions are recommended:

- Inspect the main saltwater circulating pumps prior to BOH, in accordance with PMS requirement C-1 of MIP E-5/59-28. The decision on whether or not to overhaul the main circulating pumps during BOH, in accordance with TRS 0256-086-601, should be made on the basis of the results of that inspection and the results of POT&I.
- Include an engineered task in the CMP for depot level accomplishment of class B overhauls during ROH for the main saltwater circulating pumps at 10-year intervals, in accordance with TRS 0256-086-601.

3.9.2 Main Saltwater Circulating Pump Turbine (APL 057950079)

Background

The main circulating pump turbine consists of a single-stage, radial flow, multi-impulse-type steam turbine and single helical-type double reduction gear and the turbine rotor is rigidly connected to (and supported by) the reduction gear, high-speed pinion. The entire unit is vertically mounted on the main circulating water pump and the pump rotor is rigidly attached to the reduction gear output shaft. The reduction gear absorbs the thrust loading of the pump rotor.

The turbine is manufactured by the Whiton Division of the Terry Steam Turbine Company. Because the turbines are identical in both classes, the analysis has been performed by regarding these ships to be essentially one class.

Discussion

The main circulating pump turbines contributed 14.9 man-hours per component per operating year to the maintenance burden of the CG-16 and CG-26 Class ships. The turbine governor systems (Leslie regulators) are the only significant systems that contribute routinely to the turbine intracycle maintenance burden, according to discussions during ship visits. The governor system, designed to operate the turbine at a constant speed, has three principal components: a mechanical flyweight assembly, a pilot valve, and a steam admission valve. Maintenance of this system has consisted of component overhaul and replacement of parts subject to wear in each of the three components. Only one part has been replaced with significant frequency; the governor valve stem (NSN 1H 2825-00-659-9912) was replaced 14 times during the period 1 January 1970 through 31 December 1977. This part mechanically links the pilot valve to the steam admission valve. However, the valve stem's replacement rate [one per 16 component operating years (COY)] is not considered excessive. The governor is considered generally reliable; because it can be easily bypassed, allowing operation of the main circulating pumps even with a governor failure, its operation is not considered critical. MDS data and conversations with ship's force personnel indicate that maintenance on the governor will generally be within ship's force and IMA capabilities. The historical maintenance data indicate that there will be some maintenance required during the intracycle period. Ship's force personnel stated that the Leslie regulators needed overhaul "every couple of years," but ARINC Research personnel were unable to verify the maintenance interval estimate of ship's force personnel using MDS data. Because of the non-critical nature of the governor, and the ability of ship's force to accomplish repairs, a "run-to-failure" strategy is appropriate for the Leslie regulators.

CASREP data indicate that the turbine lube oil system is another cause of significant maintenance actions. These failures are quite infrequent, but they can be catastrophic to the turbine. Of the 12 CASREPs on the turbines of the CG-16 and CG-26 Classes between 1972 and 1978, eight were caused by lube oil failures, three could be attributed to the governor and root steam valve; only one involved a damaged turbine rotor. Lube oil problems are reported infrequently in the MDS and are random in nature. The CASREP rate of 12 failures in 95 ship operating years (approximately one failure every 16 component operating years) is minimal and further reduction in the frequency of their occurrence by revisions to planned maintenance does not appear to be practical.

The main circulating pump turbines are considered reliable and will provide service through the extended operating cycle without major maintenance (with the exception of anticipated overhauls of the Leslie regulator steam governors -- such overhauls being within the capabilities of the IMA). The maintenance strategy for the main circulating pump turbines is closely related to that of their attached pumps. The PMS requirements (mentioned previously in the pump subsection) are adequate. The main circulating pump turbines have not been overhauled during every scheduled overhaul period in the past, and NAVSEA 522 (formerly NAVSEC 6145) personnel assert that

only class C repairs to turbine peripherals should ever be required. On the basis of parts-usage data, CASREP analysis, and conversations with ship's force and NAVSEA 522 personnel, it is concluded that IMA level class C repairs should be performed each ROH as specified by POT&I and the ships' CSMP. The turbine should receive a class B overhaul in accordance with TRS 0256-086-614 at the same time as its associated pump (every 10 years) to ensure continued reliable operation. The DDEOC repair requirements for BOH for both the CG-16 and CG-26 Classes currently specify class B overhaul of the main circulating pumps and turbines. These requirements should be changed to reflect accomplishment of class B overhauls only when specified as the result of POT&I and the cyclic PMS requirement to inspect the pumps' internal parts.

Recommendations

The following actions are recommended:

- Perform IMA level class C repairs on each main circulating pump turbine during BOH, as shown to be necessary by POT&I and CSMP. If the associated main circulating pump is determined to require class B overhaul, perform a depot level class B overhaul during BOH in accordance with TRS 0256-086-614.
- Delete the requirement to overhaul the main circulating pumps and turbines from the DDEOC repair requirements for BOH for both the CG-16 and CG-26 Classes.
- Include an engineered task in the CMP for depot level accomplishment of class B overhaul of the main saltwater circulating pump turbines, in accordance with TRS 0256-086-614, during ROH at 10-year intervals.

3.9.3 Auxiliary Saltwater Circulating Pumps

The auxiliary saltwater circulating pumps of the CG-16 and CG-26 Class ships are constructed similarly and are functionally identical. These auxiliary pumps are horizontally mounted, single end suction, single stage, centrifugal pumps. The APLs and associated maintenance burdens are shown in table 3-37. The auxiliary circulating pumps have been a considerable maintenance problem to ship's force personnel. During the period 1 January 1970 through 31 December 1977, 257 significant maintenance actions requiring replacement of internal pump parts were performed. (A significant maintenance action is considered to be any maintenance action that requires replacement of any internal parts, such as impellers, wearing rings, and bearings.) The average interval between significant maintenance actions (maintenance actions divided by component operating years) was 1.79 years for the pumps of the CG-16 Class and 1.72 years for the pumps of the CG-26 Class. These numbers are close enough to suggest equivalence among the four APLs of the two classes. In fact, the pumps with the lowest total maintenance burden shown in table 3-37 (APL 016060149 on the CG-16) had the shortest interval between significant maintenance actions -- 1.64 years. Since all of the

auxiliary saltwater circulating pumps have been requiring the same type of maintenance at approximately the same intervals, all four APLs will be discussed together.

The PMS for the auxiliary circulating pumps requires the internal parts of these pumps to be inspected annually and clearances measured. The majority of the maintenance actions were precipitated by this PMS inspection. In only 16 of the 257 repairs were pump failures identified as the cause of the maintenance action. Some of the other 241 reports of significant maintenance did not clearly identify the circumstances that precipitated the repair actions, but we can assume that many deficiencies were discovered during the annual PMS inspection. Discussions with ship's force personnel of both classes confirmed this assumption. The impeller and casing wearing rings were often discovered to be out of tolerance and were replaced. Discussions with ship's force personnel also indicated that even if wearing ring clearances were within tolerances, they were often replaced as insurance, since the great majority of time involved in this task is in gaining access to the pump and its internals.

The auxiliary saltwater circulating pumps are essential for operating associated ship's service turbine generator (SSTG) sets. However, because only two of the ship's four SSTG sets are required at any one time, the failure of an auxiliary circulating pump does not significantly reduce a ship's readiness status. Repair of these pumps is within ship's force capability and can generally be accomplished within one day. The only circumstances when outside assistance is required is in the event of severe casing erosion or corrosion. If the auxiliary saltwater circulating pumps were allowed to run until they were no longer capable of supplying enough cooling water to maintain auxiliary condenser vacuum, their expected times between overhauls would be significantly extended. Both NAVSEA 532 (formerly NAVSEC 6153D) and ship's force personnel strongly endorsed that conclusion and both agreed that a "run-to-failure" policy should be adopted for the auxiliary saltwater circulating pumps. Seventy-two impellers were replaced during the data period. This corresponds to one impeller replacement every 6.25 years. Whether or not the auxiliary circulating pumps would perform satisfactorily for that length of time could not be verified from the data; however, the annual inspection of pump internals and the resultant frequent replacement of components cannot be justified. The maintenance strategy for the auxiliary circulating pumps should be "run-to-failure" for the following reasons: (1) the pumps are not critical to the ship's mission effectiveness, (2) the pumps can be repaired by ship's force, and (3) the current inspection requirements are believed to be increasing the maintenance burden, rather than decreasing it. The periodicity of the PMS requirement for an annual inspection of pump internals, as specified by MRC A-1 of MIP A-019/225-18, should be changed to "R" -- as required -- and be accomplished only when there is evidence that the pump is not performing its function properly (that is, when there is such evidence as noise, vibration, low pressure, or reduction of condenser vacuum).

Recommendations

The following actions are recommended:

- Change the periodicity of PMS inspection A-1 on MIP A-019/225-18 from annual to "as required".

- Delete the requirement to routinely overhaul auxiliary circulating pumps at baseline overhaul from the DDEOC repair requirements for BOH. These pumps should be overhauled only if a POT&I or the ship's CSMP indicates that it is necessary.

3.9.4 Auxiliary Saltwater Circulating Pump Motors

Background

Each auxiliary circulating pump is close-coupled to and driven by a 15 hp motor. Four of the ships of the CG-26 Class have motors manufactured by Westinghouse (APL 174802516); the other 14 ships of the two classes use Reliance Electric Company motors (APLs 174750859 and 174751861).

Discussion

Parts-usage analysis of MDS reports revealed that motor bearings were replaced a total of 66 times on CG-16 and CG-26 Class ships during the data period 1 January 1970 through 31 December 1977. This corresponds to an average replacement rate of one per motor each 6.8 years. Bearing replacement is well within the capabilities of ship's force. In fact, IMA assistance was required for auxiliary circulating pump motor repairs in only 18 maintenance actions over the eight-year data period.

The reported maintenance burdens (table 3-37) for the auxiliary circulating pump motors ranged from 3.2 to 5.6 man-hours per component per operating year. These burdens are considered minimal. Ship's force personnel report that these motors are reliable and often bearings are replaced only because access is convenient during pump repairs. It is concluded that a "run-to-failure" policy for these motors is appropriate because of their low maintenance burden, the random nature of failures, and the capability of ship's force (assisted by an IMA) to repair the motors. Because of the random and infrequent nature of motor failures, no benefit will result from the routine overhaul of these motors during BOH or ROH.

Recommendations

As a result of the analysis, the following action is recommended: delete the requirement to routinely overhaul the auxiliary circulating pump motors, in accordance with the TRS at baseline overhaul, from the DDEOC repair requirements for BOH. The auxiliary pump motors should be overhauled only if a POT&I or the ship's CSMP indicates that it is necessary.

3.10 FUEL OIL SERVICE SYSTEM (SWABs 261-1 and -2)

3.10.1 Description

Each CG-16 and CG-26 Class ship is equipped with a fuel oil service system to supply fuel oil, either Navy distillate (ND) or diesel marine fuel (DFM), to the main propulsion boilers. Major components of this system are the main fuel oil service pumps, turbines, and pressure-regulating valves; the port and cruising fuel oil service pumps and motors; and the duplex strainers. Table 3-38 presents a summary of the MDS burden data reported against components of the fuel oil service systems of the CG-16 and CG-26 Classes (although part of this system, the fuel oil quick-closing valves are addressed with the fuel oil burners in section 3.2.10.5. Because there are shipalts to replace the valves, and shipalt installation is recommended for BOH, no further discussion of the valves is presented in this report).

3.10.2 Fuel Oil Service System Modifications

Before or during BOH, all CG-16 and CG-26 Class ships will be modified to accept the vented plunger atomizer burners in accordance with shipalts CG-16-1094K and CG-26-242K, which replace the existing burners and reduce the fuel oil service system operating pressure from 1,000 psig to 350 psig. Major benefits resulting from the modifications include the following:

- "reduced fuel oil pump power requirements
- reduced fuel oil pump loading
- elimination of gas entrainment in the system
- elimination of fuel oil coolers and the fuel oil return system"*

An improvement in fuel oil service pump and turbine reliability, as well as reduced corrective maintenance man-hour burdens for fuel oil service system equipments, should occur. The reduced loading and consequent improvement in pump and turbine reliability should reduce the material condition degradation that historically has resulted in routine pump and turbine overhauls during ROHs.

3.10.3 Main Fuel Oil Service Pumps

3.10.3.1 Background

Each CG-16 and CG-26 Class ship is equipped with four turbine-driven DeLaval IMO main fuel oil service pumps, supported by APLs 016160761, 016170758, or 016160759. Although three different APLs support the pumps, the pumps are identical and will be discussed in this report without respect to APL.

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*Taken from the ship alteration record for shipalt DLG/CG-26-242K and DLG/CG-16-1094K.

Table 3-38. MDS BURDEN SUMMARY FOR FUEL OIL SERVICE SYSTEM EQUIPMENTS

Equipment	Class	APL	Population	Total Ship Operating Time (Ship Years)	JCNs	Ship's Force Man-hours	IMA Man-hours	Total Man-hours	Average Man-Hours per Equipment per Operating Yr.
Main Fuel Oil Service Pumps	16	016160761	36	43.4	172	3,124	641	3,765	21.7
	26	016160758 016160759 016160761	36	45.0	155	2,511	1,400	3,911	21.7
Main Fuel Oil Service Pump	16	057150171	36	43.4	191	2,450	664	3,114	17.9
	26	057150171 057150190 057150196	36	45.0	152	553	520	1,073	6.0
Fuel Oil Service Pump Regulating Valve	16	882260191	36	43.4	148	724	213	937	5.4
	26	882260287	20	24.6	111	606	794	1,400	14.2
		882260387	16	20.4	120	858	689	1,547	19.0
Port and Cruising Fuel Oil Pumps	16	016160739	18	43.4	50	615	81	696	8.0
	26	016160739	18	45.0	47	1,059	277	1,336	14.8
Port and Cruising Fuel Oil Pump Motors	16	174750716	18	43.4	9	163	330	493	5.7
	26	174180151	8	20.4	1	10	0	10	<1
		175503454	10	24.6	2	6	0	6	<1
Duplex Strainers	16	750080106	8	18.8	22	128	476	604	16.1
		750440011	6	14.6	15	82	305	387	13.2
		750030172	4	10.0	9	81	1	82	4.1
	26	750080110	8	20.4	0	0	0	0	0
		750440014	10	24.6	0	0	0	0	0

3.10.3.2 MDS Summary

From the MDS burden summary data presented in table 3-38, it can be seen that the main fuel oil service pumps experienced an average of about 22 man-hours per pump per operating year during the data period. A review of the MDS narrative transaction data showed that this burden resulted from two types of repetitive maintenance actions, either overhaul and major pump repairs or repair of fuel oil service piping and gauge lines. These two types of maintenance actions accounted for about 72 percent of the fuel oil service pump man-hour burden reported in the MDS.

A total of 85 JCNs and 4,770 man-hours (4,144 ship's force man-hours and 626 IMA man-hours) were reported for pump overhauls and major repairs. Major repairs included power or idler rotor replacement, mechanical seal replacement, or other repairs requiring disassembly of the pump; such major repairs averaged about 56 man-hours per repair. Because of the repetitive nature of these repairs, it is concluded that some major repairs or overhauls are to be expected during a 60-month operating cycle. With the installation of the vented plunger atomizer burner shipalts and the reduced loading expected to result, a reduction in the number of these major repairs or overhauls is also expected. Therefore, although some major repairs or overhauls are likely to be required during an extended operating cycle, the number and frequency of major repairs and overhauls should be reduced. The established ship's force capability to make major pump repairs and to overhaul the pumps, as shown by the difference between the man-hours reported by ship's forces and IMAs, leads to the conclusion that ship's forces can make virtually any pump repair that is required during an extended operating cycle, with some assistance from IMAs. Consequently, it is recommended that the pumps be maintained during the operating cycle according to a run-to-failure strategy. Ship's forces can make most repairs and can be assisted by IMAs as necessary.

Piping and gauge line repairs had a total reported burden of 23 JCNs and 730 man-hours (216 ship's force man-hours and 514 IMA man-hours) which resulted primarily from piping deterioration. The 23 piping JCNs correspond to a repair rate of 0.26 repairs per ship per operating year, which indicates that piping and gauge line repairs are infrequent. An average of about 32 man-hours was reported for each of these repairs. The vented plunger atomizer burner does not require fuel oil return piping, so the fuel oil return piping can be removed. However, the shipalts suggest that the required boiler fuel oil start-up recirculating piping be installed by connecting that piping to the existing return-flow piping, instead of installing special new piping. Thus some of the fuel oil return piping will remain after shipalt installations are complete. Therefore, although piping and line repairs have been infrequent, the piping and lines must be in good condition during the operating cycle because of the danger of fuel oil leaks. In order to accomplish this the piping and lines should be visually inspected and ultrasonically tested for deterioration during BOH and ROH and repaired as necessary.

3.10.3.3 Parts-Usage Summary

A review of the MDS parts-usage data showed that only the mechanical seal experienced repetitive usage during the data period. A total of 24 seals were replaced -- a 49 percent ratio of replacements to total population, which corresponds to about 0.55 percent of the seal population per seal per operating year. None of the other parts experienced usage that exceeded 25 percent of the part population, leading to the conclusion that except for mechanical seals, part replacements are not likely to be repetitive during the operating cycle. This conclusion will apply especially after installation of the vented plunger atomizer burner shipalts, which will reduce system operating pressure and thus decrease pump loading.

3.10.3.4 CASREP Summary

A review of the fuel-oil service system CASREP data determined that 15 CASREPs were submitted during the period 1 January 1976 through 31 August 1978, yielding a CASREP every 12 pump-years. The predominant reported failure (eight CASREPs submitted) was low output, which was apparently caused by wearout. Seal leakage was reported in four CASREPs; miscellaneous nonrepetitive valve failures were reported in the remaining three CASREPs. All of the CASREPs had a severity code of C-2, which indicates only minor degradation of ships' primary missions. Because of the low submission rate and the submission of CASREPs with the low severity code of C-2, it is concluded that the significance of failure of the fuel oil service pumps is low.

Downtime for these 15 CASREPs totaled 7,596 hours, or an average of about 21 days per CASREP. A majority of this downtime was reported for the eight low-output failures and totaled 5,033 hours, or an average of about 26 days per CASREP. Inadequate supply support totaled 1,494 hours (62 days) and time awaiting maintenance totaled 3,539 hours (147 days) for an average of about eight and 18 days per CASREP, respectively. Seal leakage was reported in four CASREPs and totaled 1,544 hours (64 days), with a majority of the time (1,400 hours, or about 91 percent) reported as awaiting maintenance. On the basis of these data, it is concluded that while occurrence of such failures can lead to extensive fuel oil service pump downtime, failures that degrade mission capability have been infrequent and are unlikely to be repetitive or to present a problem during the operating cycle.

3.10.3.5 PMS Summary

All fuel oil service pumps are supported by MIP F-4/14-78, which is considered adequate to maintain the pumps during the operating cycle. This MIP is limited to tests of the discharge relief valve and inspections of the mechanical seal for leaks, and it follows the manufacturer's recommendations for preventive maintenance. This analysis did not identify any necessary changes to this MIP.

3.10.3.6 ROH Repair History and DDEOC BOH Repair Requirements

A review of the CG-16 and CG-26 Class repair profiles showed that the fuel oil service pumps were routinely overhauled during ROH. These overhauls were reported in eight of 11 CG-16 Class SARPs and in 10 of 11 CG-26 Class SARPs, which indicates that pump overhauls have been repetitive. In addition, the DDEOC BOH repair requirements for both classes specify TRS overhauls of all four pumps during BOH on the basis of 1200 psi steam propulsion plant improvement program recommendations. The MDS and CASREP data presented above show that some major repairs are to be expected during an extended operating cycle with only minor degradation of ships' primary missions. With the installation of the vented plunger atomizer burners and the resultant reduced pump loading, pump reliability should improve. This action should result in acceptable pump operation during the operating cycle. Because of the low significance of pump failure and of ship's forces established capability to maintain the pumps, routine overhaul of all four installed pumps during BOH is not warranted. However, because of the historical ROH repair history that indicates that repetitive overhauls were performed, and because of the likelihood that some major repairs will be required during an extended operating cycle, it would be prudent to overhaul those pumps which would obtain the maximum benefit from an overhaul. Therefore, anticipating that some pumps will require overhaul to ensure acceptable operation during an extended operating cycle, qualified tasks should be included in the CG-16 and CG-26 CMPs to overhaul two of the four installed fuel oil service pumps during BOH and ROH in accordance with the applicable TRS. The pumps to be overhauled should be selected on the basis of the POT&I results and each ship's CSMP. Ship's forces should make class C repairs to the other two pumps as shown to be necessary by the POT&I results and each ship's CSMP. Implementing this strategy will place the pumps on (essentially) a 120-month overhaul cycle.

3.10.3.7 Recommendations

The following recommendations are made:

- Maintain the fuel oil service pumps according to a run-to-failure maintenance strategy during the extended operating cycle. Ship's forces should repair the pumps when required during the cycle, with IMA assistance provided as necessary.
- Include engineered tasks in the CG-16 and CG-26 CMPs to overhaul two of four installed fuel oil service pumps during ROH in accordance with TRS 0261-086-601. Select the pumps on the basis of POT&I results and each ship's CSMP. Include qualified tasks in the CMPs to have ship's forces make class C repairs to the remaining two pumps on the basis of the POT&I results and each ship's CSMP. Accomplish the same repairs during BOH.
- Visually inspect and ultrasonically test the piping and gauge lines and repair them as necessary during BOH and ROH. Include this maintenance as an engineered task in the CG-16 and CG-26 CMPs for depot accomplishment during ROH. Add this task to the DDEOC BOH repair requirements.

- Delete the routine overhaul of all four installed pumps from the DDEOC BOH repair requirements.

3.10.4 Main Fuel Oil Service Pump Turbines

3.10.4.1 Background

Each main fuel oil service pump is driven by a single-stage DeLaval model HCDM steam turbine. A transmission reduces the turbine input shaft speed to the pump operating speed and is connected to the pump by a flexible coupling. Although three APLs support the turbines installed on the CG-16 and CG-26 Classes (APLs 057150171, 057150190, and 057150196), the turbines are identical and were analyzed together, rather than by APL.

3.10.4.2 MDS Summary

Table 3-38 presents a list of the maintenance burdens reported against the individual APLs that support the turbines. When combined, the burden reported against all the turbines totaled 343 JCNs and 4,187 man-hours (3,003 ship's force man-hours and 1,184 IMA man-hours). The man-hour burden averaged 11.8 man-hours per turbine per operating year. About 72 percent of this burden (3,011 man-hours) was the result of major turbine repairs (which included repairs such as overhaul, carbon packing replacement, and bearing replacements) or repairs of piping (including valves and gauge lines). Forty-one major turbine repairs and 41 piping repairs were reported, for a total of 82 repairs.

A total of 2,109 man-hours were reported for the 41 major turbine repairs. Ship's forces reported 1,997 man-hours (95 percent of the total man-hours) and IMAs reported 112 man-hours (5 percent), indicating that ship's forces seldom required IMA assistance to repair the turbines. About half of the major repairs (21 of 41 reported repairs) reported overhaul, while the remainder of the repairs reported bearing and carbon packing replacements. Although infrequent some major turbine repairs can be expected during an extended operating cycle, with each repair averaging about 51 man-hours. Because of the redundant pump and turbine installations and ship's forces established repair capability, it is concluded that scheduling turbine overhauls during the operating cycle is unwarranted. Therefore, the turbines should be maintained according to a run-to-failure maintenance strategy and should be repaired as required during the operating cycle by ship's forces, with IMA assistance provided as necessary.

Piping repairs (including valve and gauge-line repairs) accounted for about 22 percent of the turbine maintenance man-hour burden (902 man-hours). Ship's forces reported 422 man-hours (47 percent of total man-hours) and IMAs reported 480 man-hours (53 percent) for the 41 repairs. Most of the MDS narratives for these repairs reported repairing deterioration or leaks, which can be considered safety-related problems, and reported an average of 22 man-hours for each of those types of repairs. Although the piping repairs have not been frequent, the deterioration is continuous and can

be expected to be detected during an extended operating cycle through the continued use of MRC R-1 on MIP A-700/5-29. This MRC specifies inspecting the fuel oil piping before each boiler light-off when the piping is at fuel oil operating pressure. Because of the random nature of the deterioration, piping, valves, and gauge lines should be replaced during BOH, ROH, and the operating cycle whenever deterioration is detected.

3.10.4.3 Parts-Usage Summary

Three parts -- the carbon packing, the inboard bearing, and the thrust bearing -- experienced repetitive usage during the data period, as indicated by their ratios of replacement to population of 76, 53, and 53 percent, respectively. None of the other parts used experienced repetitive usage.

Usage of the carbon packing, which is normally replaced in sets of four pieces, averaged about one set every one and one-half ship operating years, which indicates that carbon packing replacement can be expected several times during an extended operating cycle (total usage was 219 pieces of carbon packing). Carbon packing replacement is within ship's force capability and does not require turbine disassembly; therefore, downtime is minimized whenever packing fails.

Conversely, replacement of the inboard and thrust bearings requires partial turbine disassembly. The usage rate was the same for each bearing (total usage was 38 of each bearing); usage averaged about 2.3 bearings per ship per operating year. Because of the number of turbine overhauls reported in the data, most of the bearings were assumed to have been used primarily during the reported overhauls, with few separate actions reporting bearing failure and replacement. Other than replacements during overhauls, bearing replacements will not be repetitive during the operating cycle.

3.10.4.4 CASREP Summary

CASREP data for the period 1 January 1976 through 31 August 1978 included only four CASREPs that were submitted against the main fuel oil service pump turbines, or about one CASREP every 50 turbine-years. This submission rate is equivalent to one CASREP approximately every 48 to 50 turbine-years (one every 12 ship-years) and leads to the conclusion that turbine failures have not seriously degraded ships' missions. This conclusion is further substantiated by the reported severity code of C-2 for all four CASREPs, which indicates that only minor mission degradation occurred as a result of the failures. CASREP reported downtime totaled 1,943 hours (about 81 days) and resulted predominantly from supply support delays. Downtime awaiting maintenance totaled 802 hours (41 percent of total downtime, or 33 days), while the downtime awaiting supply totaled 1,141 hours (59 percent of total downtime, or about 48 days). Downtime, therefore, averaged 486 hours per CASREP (20 days per CASREP), with supply downtime accounting for about 285 hours (12 days) and downtime awaiting maintenance accounting for 200 hours (eight days). Thus if mission degrading turbine failures occur, turbines are likely to be down awaiting either supply or maintenance for about 20 days.

Because of the low submission rate for turbine CASREPs, it is concluded that mission degrading failures are likely to be infrequent during the operating cycle. Also, the low submission rate and the redundant pump and turbine installations make the significance of turbine failure low.

3.10.4.5 PMS Summary

The main fuel oil service pump turbines are maintained according to MIP F-4/14-78, which contains several condition assessment requirements. These requirements specify inspections and measurements of thrust and inboard bearing clearances and address the two bearings that have experienced repetitive usage. Therefore, the PMS for the turbine is considered to be adequate to maintain the turbine throughout an extended operating cycle, because its procedures help to identify potential bearing failures and to permit the scheduling of bearing replacement during a convenient period.

3.10.4.6 ROH Repair History and DDEOC BOH Repair Requirements

As with the main fuel oil service pumps, there is good correlation between the repair histories of the turbines installed in the CG-16 and CG-26 Classes. The CG-16 Class repair profile reported that in eight of 11 SARPs, all four turbines were overhauled to class B standards. Similarly, the CG-26 Class repair profile reported turbine overhauls to 10 of 11 SARPs. Both DDEOC BOH repair requirements documents specify overhaul of all four turbines at BOH, either to class B standards or in accordance with the TRS. Because ship's forces have shown the ability to repair the turbines when failures have occurred -- failures which did not seriously degrade ships' missions and which did not incur extensive turbine downtime -- and because of the redundant pump and turbine installations, it is concluded that routinely overhauling the turbines during BOH is not warranted. Repairs should be identified before BOH by accomplishing a POT&I and referencing each ship's CSMP. Repairs to be accomplished during ROH should be identified in the same way. Necessary overhauls should be performed in accordance with the applicable TRS. Scheduling intracycle repairs is not required.

The CG-16 Class repair profile also reported repetitive repairs of the fuel oil piping, after the affected areas were identified by NDT (nondestructive test). Although the CG-26 Class repair profile did not list any piping repairs, both the CG-16 and CG-26 Class DDEOC BOH repair requirements documents specify testing the piping in accordance with 1200 psi Propulsion Plant Test and Certification Manual [test procedures 261F5070030, appendixes 30 (CG-16) and 39 (CG-26)], which specify inspecting, flushing, and hydrostatically testing the piping to ensure that no leaks are present. Although a hydrostatic test is not usually considered to be a nondestructive test, successful completion ensures that no leaks exist (therefore, a safe system exists) when the fuel oil system reenters service. Therefore, the specified DDEOC BOH repair requirements for fuel oil piping should be accomplished during BOH.

3.10.4.7 Recommendations

The following actions are recommended:

- Include qualified tasks in the CG16 and CG-26 CMPs to have a depot activity repair the main fuel oil service pump turbines during ROH, on the basis of POT&I results and each ship's CSMP. Make the repair during BOH. Overhauls necessary during either BOH or ROH should be accomplished in accordance with TRS 0261-086-600.
- Repair the fuel oil piping during BOH in accordance with the DDEOC BOH repair requirements.
- Include qualified tasks in the CG-16 and CG-26 CMPs to test and repair the fuel oil piping during ROH in accordance with 1200 psi Propulsion Plant Test and Certification Manual, test procedure 261F5970030, appendixes 30 (CG-16) and 39 (CG-26).

3.10.5 Fuel Pressure Regulating Valves

3.10.5.1 Background

One Leslie CTHVNS-1, CTHVNS-2, or CTHNS-3 pressure regulating governor valve is installed on each main fuel oil service pump turbine to vary steam flow to the turbine for the purpose of maintaining constant fuel oil pressure to the burners. Three APLs (882260191, 882260287, and 882260387) support the valves installed on CG-16 and CG-26 Class ships.

3.10.5.2 MDS Summary

Table 3-38 presents a list of the burdens reported against these valves, and shows that the burden reported against APL 882260181 is about five man-hours per valve per operating year. Because of this low burden, it is concluded that the valve has operated reliably and should continue to do so during an extended operating cycle. Therefore, the valve should continue to be maintained according to existing PMS, should be repaired by ship's forces during the operating cycle, and should be repaired during BOH and ROH as shown to be necessary by POT&I and each ship's CSMP.

The maintenance burden reported against the other two APLs indicates that much more corrective maintenance was required for them to maintain acceptable operation. This burden totaled 231 JCNs, 1,464 ship's force man-hours, and 483 IMA man-hours, for a total of 2,947 man-hours and an average of 16.4 man-hours per valve per operating year. Overhauls, hunting, damage, wearout, lagging repairs, and operating gear repairs accounted for a majority of this burden with a reported total of 122 JCNs (53 percent of total JCNs), 1,110 ship's force man-hours (76 percent of total ship's force man-hours), and 1,147 IMA man-hours (77 percent of total IMA man-hours), for a total of 2,257 man-hours (76 percent of total man-hours).

Overhaul and hunting accounted for most of this burden (these categories were combined because overhaul was the repair most frequently reported in the MDS narratives when hunting was described as the problem). A total of 83 JCNs, 734 ship's force man-hours, and 761 IMA man-hours (a total of 1,495 man-hours) were reported against overhaul and hunting maintenance actions. The average time between these repairs was calculated to be about two years per repair; the average maintenance burden was 18 man-hours per repair. Ship's forces and IMAs shared the maintenance burden equally, as ship's forces reported about 49 percent and IMAs reported about 51 percent of the man-hours. Discussions with ship's forces determined that assistance from Leslie technical representatives was required to correctly set the valves, because ship's forces could not correct the hunting problems they experienced. On the basis of the reported MDS data, overhaul was the most frequently reported action taken to correct the hunting problem. Thus it is likely that hunting will occur during an extended operating cycle and the ship's forces will need IMA assistance at a minimum to correct this hunting.

Damage (such as scored rotors) or wearout accounted for 34 JCNs, 328 ship's force man-hours, and 132 IMA man-hours, for a total of 460 man-hours. According to the MDS narrative data and to discussions with ship's forces, the damage and resulting wearout was caused by grit in the fuel oil. Although the average time between these repairs was calculated, valve damage is more dependent on fuel oil quality than on operating time; thus the need for repairs cannot be accurately predicted. Because of the variability in the quality of the fuel oil available to Navy ships, some damage and wearout should be expected on all ships during an extended operating cycle.

Repairs to lagging and to manual operating gear accounted for only five JCNs, but these repairs required 48 ship's force man-hours and 254 IMA man-hours, for a total of 302 man-hours. These repairs are obviously infrequent, but they accounted for about 10 percent of the valves' man-hour burden. These repairs were accomplished primarily by IMAs with some ship's forces assistance. Although nonrepetitive, these repairs may be required during BOH and ROH; the need to make these repairs should be determined by POT&I and each ship's CSMP.

3.10.5.3 Parts-Usage Summary

A list of the parts that experienced repetitive usage during the data period is presented in table 3-39, which shows that there were many valve parts used and that the usage was well-distributed across the CG-26 Class ships. There was repetitive usage of wearing parts -- piston rings, cylinder liners, disks and seats -- which was probably caused by grit in the fuel oil and by normal wear; and the adjusting springs, diaphragm, packing, and top-cap gasket, which are consistent with repairs required to correct the hunting problem. The repetitive parts usage indicates that repetitive repairs were accomplished on the valve during the data period. This fact leads to the conclusion that similar usage and repairs can be expected during an extended operating cycle.

Table 3-39. PRESSURE REGULATING GOVERNOR VALVE PARTS USAGE (APLs 882260287 AND 882760387)

Part Identification		Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of JCNs Reported	Number of Ships Reported
NSN	Nomenclature						
9C-4820-00-036-1532	Mn. Vl. Disk	1	36	21	58	12	5
9Z-5330-00-252-9215	Top Cap Gasket	1	36	67	186	3	6
9C-4820-00-288-1229	Piston Ring	2	72	142	197	40	8
9Z-5360-00-291-7114	Aux. Vl. Spring	1	36	68	189	20	6
9C-4320-00-367-1453	Cylinder Liner	1	36	74	206	27	8
9Z-5360-00-446-3362	Mn. Vl. Spring	1	36	62	172	18	7
9Z-5360-00-446-3375	Adj. Spring	1	36	38	106	15	7
9Z-5330-00-641-6309	Packing	1	36	57	158	22	8
9C-4820-00-909-3136	Aux. Vl. Disk & Seat	1	36	46	128	26	7
9C-4820-00-306-1318 9C-4820-00-949-8240	Vl. Diaphragm	3	108	271	251	53	9

3.10.5.4 CASREP Summary

Five CASREPs were submitted against these valves during the period 1 January 1976 through 31 August 1978, which is about one CASREP every 33 valve-years (when the data for APL 882260191 is included). Three of these CASREPs were submitted by CG-18, and two were submitted by CG-32. The CASREPs submitted by CG-32 had a severity code of C-3, which indicated major degradation of a ship's mission, while the other CASREPs had a severity code of C-2, which indicated only minor degradation of a ship's mission. More important than the severity code, the total reported downtime of 9,828 hours (an average of about 82 days per CASREP) indicated that the inability of ship's forces to make repairs meant that the two ships either deferred the repairs or had to wait for assistance to complete the valve repairs and close out the CASREPs. There were no downtime hours awaiting supply reported, indicating that parts support for the Leslie pressure regulating valves is adequate. The experienced CASREP submission rate indicates that mission degrading pressure regulating valve failures are not likely to be frequent during an extended operating cycle.

3.10.5.5 ROH Repair History and DDEOC ROH Repair Requirements

A review of the CG-16 and CG-26 repair profiles indicated that there were no repetitive repairs reported specifically for the pressure regulating valves. However, because regulators were included as part of the ACC/FWC/MFPC system class B overhauls listed in the CG-26 Class repair profile as recurring BOH repairs, and because the DDEOC repair requirements for BOH for both classes specify ACC/FWC/MFPC system overhauls during BOH, it is concluded that the fuel pressure regulators were routinely overhauled during ROHs and that they were intended to be overhauled during BOH.

Judging from the routine turbine overhauls reported in the repair profiles, it appears that repetitive valve failures and repairs have been experienced. Although the pumps and turbines have been shown to be reliable, the pressure regulating valve failures have appeared to limit the availability of the pumps. Because the function of providing fuel oil to boilers is lost if the valve fails, even though the pump itself is in acceptable condition, the pressure regulating valves should be overhauled during BOH and ROH by depot activities and should be adjusted, following Leslie procedures, in place on the associated turbine. Intracycle repairs can continue to be identified by ship's forces by performing the PMS.

3.10.5.6 Recommendations

The following recommendations are made:

- Include a qualified task in the CG-16 CMP for a depot activity to repair the pressure regulating valve during ROH on the basis of POT&I results and each ship's CSMP (APL 882260191). Make repairs on the same basis during BOH. Delete the routine overhauls of these valves from the DDEOC BOH repair requirements.

- Include an engineered task in the CG-26 CMP for a depot activity to overhaul the pressure regulating valves (APLs 882260287 and 8822060387) during ROH. Make the same repairs during BOH (these tasks are included with the turbine overhaul listed in the DDBOC BOH repair requirements).

3.10.6 Port and Cruising Fuel Oil Service Pump and Motor

3.10.6.1 Background

The port and cruising fuel oil service pumps and motors are used primarily during in-port steaming; these pumps are used in place of the turbine-driven main fuel oil service pumps. The service pumps are manufactured by DeLaval Turbines, Incorporated (model B12LBX118) and are supported by APL 016160739. The motors are supported by APLs 174750716, 174180151, and 175503454. Two pump and motor combinations are installed on each ship.

3.10.6.2 MDS Summary

As can be seen in table 3-38, the maintenance burden reported against the motors was low when the burden was compared to other fuel oil system components. The CG-16 Class motor (APL 174750716) had a reported burden of about six man-hours per motor per operating year; the CG-26 Class motors had a reported burden of less than one man-hour per motor per operating year. Because of these low burdens, it is concluded that the motors operated reliably during the data period and are likely to continue to do so during an extended operating cycle. The CG-16 and CG-26 Class motors should be repaired during BOH and ROH as shown to be necessary by POT&I results and each ship's CMSP.

The pumps had a reported burden of 97 JCNs, 1,674 ship's force man-hours, and 358 IMA man-hours, for a total of 2,032 man-hours and an average of 11.5 man-hours per pump per operating year. A majority of this burden, which totaled 29 JCNs and 1,576 man-hours, resulted from pump overhauls and replacement of the mechanical seals. The average time between these repairs was about six pump-years. Each repair was accomplished primarily by ship's forces, with some IMA assistance provided, and required an average of about 54 man-hours to complete. Judging by the average time between repairs, it is likely that repetitive overhauls will not be required during an extended operating cycle. If the existing PMS is performed as specified, the pumps are likely to operate satisfactorily during the operating cycle; any corrective maintenance required should be accomplished by ship's forces.

3.10.6.3 Parts-Usage Summary

In spite of the number of overhauls reported in the MDS data, only replacements of the mechanical seals could be considered repetitive, with a total of 23 seals replaced during the data period. These seals were replaced in 22 maintenance actions on 14 (of 18) ships, which indicates that the usage was evenly distributed across both classes. Ordering of major pump parts (such as power rotors and repair modules) through the

supply system was not repetitive. Further, there was no obvious correspondence between the number of overhauls reported and the number of major pump parts replaced, leading to the conclusion that either ships' forces are maintaining "bench spares" for port and cruising fuel oil service pumps, or that the reported "overhauls" never occurred. Other than mechanical seal replacements, it appears that repetitive part replacements will not occur during an extended operating cycle.

3.10.6.4 CASREP Summary

Nine CASREPs were submitted against port and cruising fuel oil service pumps during the period 1 January 1976 through 31 August 1978, which is about one CASREP every 11 pump-years. Five CASREPs were submitted for worn or damaged parts, two for leaks, and two for miscellaneous failures. A majority of the downtime, 2,680 hours (about 112 days) or about 68 percent of the CASREP total, was reported in CASREPs submitted for worn or damaged parts, with downtime awaiting maintenance predominating. Although the CASREP downtime indicates that ship's force capabilities to repair the pumps may not have been adequate, the MDS reported man-hours indicate that ships' forces reported a much higher percentage of the man-hours than did IMAs, indicating that in a majority of cases ships' forces repair capability is adequate. Pump maintenance could also have been deferred until more convenient times; therefore, CASREPs could have been submitted to indicate both reduced capability and a delay in fixing the pumps. On the basis of the CASREP submission rate and ships forces' apparent repair capability, it is concluded that mission degrading port and cruising fuel oil service pump failures are not likely to be a problem during an extended operating cycle.

3.10.6.5 ROH Repair History and DDEOC ROH Repair Requirements

There was a difference between the ROH repair histories of the pumps installed in the two classes. The CG-16 Class repair profile reported repetitive overhauls of both pumps during ROHs, as class B overhauls were reported in eight of 11 SARPs. The CG-26 Class repair profile reported no repetitive repairs for the same pumps. Both classes' DDEOC BOH repair requirements specify overhauls of both pumps in accordance with the applicable TRS, and class B overhauls of the driving motors and motor controllers. However, the data and analysis have shown that repetitive overhauls are unlikely to be required during an extended operating cycle, and that ship's forces are capable of repairing the pumps. Therefore, the routine overhauls of the pumps and motors specified in the DDEOC BOH repair requirements are judged to be unwarranted. The pumps and motors should be subjected to POT&Is before BOH and ROH and should be repaired during the overhauls as shown to be necessary by the POT&I results and each ship's CSMP.

3.10.6.6 Recommendations

The following actions are recommended for the service pumps and motors:

- Include tasks in the CG-16 and CG-26 CMPs for depot activities to repair port and cruising fuel oil service pumps and motors

during ROH as shown to be necessary by POT&I results and each ship's CSMP. Make repairs on the same basis during BOH.

- Delete the routine port and cruising fuel oil service pump, motor, and controller overhauls from the DDEOC BOH repair requirements documents.

3.10.7 Duplex Fuel Oil Strainers

Two fuel oil system strainers are installed on each ship (one per fireroom) between the pumps and the burners to filter the fuel oil before it enters the burners at the boiler front. Three manufacturers supplied strainers for the CG-16 and CG-26 Class ships; Andale Company (APL 750030172); Bethlehem Steel Corporation, Shipbuilding Department (APLs 750080110 and 750080106); and Bath Iron Works (APLs 7500440011 and 7500440014).

3.10.7.1 MDS Summary

Because there were no man-hours reported against APLs 750080110 and 750440014 (which are installed on the CG-26 Class ships), it is concluded that those strainers operated reliably during the data period and that similar operation can be expected during an extended operating cycle. The strainers can continue to be maintained according to the PMS and to be repaired during BOH and ROH as shown to be necessary by the PMS inspections and each ship's CSMP.

However, the strainers installed on CG-16 Class ships (APLs 750080106, 750440011, and 750030172) had a reported burden that indicates that some corrective maintenance had occurred during the data period. A list of the individual maintenance burdens for the strainers is presented in table 3-38; this table shows that the maintenance burdens for the three strainers, when combined, totaled 46 JCNs, 291 ship's force man-hours, and 782 man-hours, for a total of 1,073 man-hours and an average of 12.4 man-hours per strainer per operating year. Only four of nine applicable ships reported maintenance man-hours against the strainers. Two major categories of repairs accounted for a substantial majority (86 percent) of the strainer maintenance burden -- correction of leak-through and safety-related repairs.

Approximately 75 percent (802 of the reported 1,073 man-hours) of the man-hours were reported for correction of leak-through in 10 repair actions. About eight percent (66 man-hours) of the man-hours were reported by ship's forces and about 92 percent (736 man-hours) were reported by IMAs, indicating that the primary strainer repair capability resided at the IMA level. The average time between strainer repairs was calculated to be 8.7 strainer-years per repair, while each repair required an average of 80 man-hours to complete. It is judged that repetitive repairs of strainer leak-through will not be required during an extended operating cycle. Individual strainer failures should be repaired by IMAs as required during the operating cycle.

Similarly, the safety-related strainer actions were also infrequent, with an average time between repairs of about 10.8 strainer-years per repair.

These repairs included manufacture of strainer shields and drip pans; such repairs should not be repetitive during an extended operating cycle, and can be accomplished on an as-required basis.

3.10.7.2 Parts-Usage and CASREP Summaries

Parts-usage and CASREP submittals were also not repetitive during the data period, as only a few strainer elements were replaced. Also, no CASREPs were submitted against the strainers. Thus strainer failures are not usually considered mission degrading by ship's force. Parts usage will likely remain nonrepetitive and CASREP submissions will be infrequent or nonexistent during an extended operating cycle.

3.10.7.3 PMS Summary

Fuel oil system duplex strainers are maintained according to MIP E-44/17-68, which contains two requirements specifically applicable to duplex strainers and several requirements applicable to simplex strainers. Included in these requirements are an inspection of strainer shields and a requirement to shift, inspect, and clean strainers when the pressure drop across the strainer is more than three percent of the system operating pressure. These requirements should be adequate to maintain the strainers during an extended operating cycle, and should be performed before BOH and ROH to define any necessary repairs that should be accomplished during these overhauls.

3.10.7.4 ROH History and DDEOC BOH Repair Requirements

A review of the CG-16 and CG-26 Class repair profiles identified no repetitive repairs that were historically accomplished during ROHs. The DDEOC BOH repair requirements for both classes specify that both duplex strainers should be overhauled either to class B standards or in accordance with a TRS during BOH. However, as shown above, there were no repetitive repairs that are likely to occur during an extended operating cycle. Although IMAs have the primary repair capability for the strainers, the infrequent repairs indicate that mission degrading failures are unlikely during the cycle. Therefore, the fuel oil system duplex strainers should be maintained during the operating cycle in accordance with PMS, and repaired during BOH and ROH as shown to be necessary by the PMS inspections and each ship's CSMP. The routine overhauls of duplex strainers specified in the CG-16 and CG-26 Class DDEOC BOH repair requirements should be deleted.

3.10.7.5 Recommendations

The following actions are recommended:

- Include qualified tasks in the CG-16 and CG-26 CMPs for IMA activities to repair the fuel oil system duplex strainers during ROH as shown to be necessary by the PMS inspections and each ship's CSMP. Make repairs during BOH on the same basis.
- Delete the routine overhauls of duplex strainers from the CG-16 and CG-26 Class DDEOC BOH repair requirements.

3.11 MAIN PROPULSION LUBRICATING OIL SYSTEM (SWAB 262-4)

The lubrication systems consist of an independent forced feed service system in each engine room for lubricating the propulsion units and a separate fill and transfer system for filling the lube oil tanks, transferring oil between tanks, and purifying the oil. The transfer system also permits transferring lube oil to and from the turbogenerators, main feed pumps and forced draft blowers.

The lubricating oil service system of each plant is designed to operate as a constant pressure system that serves the main propulsion turbines and reduction gears. No cross connection between the forward and after plants exists for the service systems. Each system consists of a sump at the base of the reduction gear unit; a turbine-driven (standby) lube oil service pump; a motor-driven (emergency) lube oil service pump; an attached lube oil service pump, which is driven off the main reduction gear; a duplex magnetic type discharge strainer; a lube oil cooler; and the necessary piping and fittings for effective circulation and control of the lubricating oil (Military Symbol 2190 TEP).

The lubricating oil service system is designed to provide approximately 15 psig pressure at all turbine bearings when the system is supplied with oil from the service pumps. Since the attached lube oil pump is driven off the main reduction gear, the pump is in operation all the time that the propulsion unit is in ahead operation. (Lubrication for the attached lube oil service pump itself is provided by oil taken from the reduction gear oil header through a line within the reduction gear casing.) The turbine-driven standby pump idles (at shaft speeds above 185 rpm), while the attached pump is carrying the load. During astern operations, the attached pump does not contribute to the lubrication requirements of the unit. During periods of starting, stopping, and low speeds, the attached pump is not driven at a speed fast enough to develop the required lube oil pressure at the most remote bearing. Consequently, the speed of the turbine-driven (standby) lube oil pump automatically increases to augment the supply from the attached pump or to supply the total amount of lube oil.

Pump control is accomplished with a steam regulating (constant pressure) governor that speeds up the pump when the supply from the attached pump is no longer sufficient to maintain the required oil pressure. (The pressure-sensing line to the governor is taken from the lube oil header.)

The motor-driven lube oil service pump functions as an emergency unit that is configured for either manual or automatic start but with manual shutoff only. Automatic starting is effected by using a pressure switch that is set to start the pump at the instant the header pressure falls below a predetermined value.

The only system components selected for analysis were the lube oil purifiers, the turbine-driven (standby) lube oil service pumps, and the lube oil duplex strainers. The remaining lube oil system components were

not selected for analysis because of insignificant maintenance reported against their APLs. A maintenance burden summary for the selected components is provided in table 3-40.

The main lube oil system components are identical in function and, in many cases, equipments across the two classes. Therefore, the components for both the CG-16 and CG-26 Classes are discussed together.

3.11.1 Lube Oil Purifier

3.11.1.1 Background

All ships of the CG-16 and CG-26 Classes are equipped with two Penwalt Corporation Equipment Division (formerly Sharples Corporation) type 14VN2P centrifugal lube oil purifiers (APL 760010033 or 760010087). The type 14VN2P purifier represents a proven and conservative design. This purifier is known to be dependable and relatively maintenance-free if it is given the care and maintenance recommended by the manufacturer. However, the CG-16 and CG-26 Class ships have reported a significant maintenance burden against the lube oil purifiers (19.6 man-hours per component per operating year). There were 27 CASREPs against the lube oil purifiers between 1 January 1972 and 31 August 1978 (one CASREP every seven purifier-years).

Table 3-41, a parts-usage summary, provides an indication of the sources of purifier problems. Most of the high-usage parts can be related directly to problems focused in three bearing assemblies: spindle bearing, drag bearing, and idler pulley bearing. This analysis has identified the following seven problems within type 14VN2P purifiers of the CG-16 and CG-26 Classes:

- High replacement rates for ball bearings associated with the spindle bearing assembly
- High replacement rates for spindle flexible couplings
- High replacement rates for the ball bearings of idler arm pulleys
- Frequent oil leaks through the rotary seals of purifier seals
- Excessive wear of drag shells and bowl boss sleeves
- Excessive vibration of the purifier bowls during operation
- Damage to purifier bowls and covers following failure of other parts

Subsequent discussions in this section will address the causes of these problems and the recommended solutions to these problems.

3.11.1.2 Discussion

Spindle Bearing Problems

On the basis of (1) a detailed review of the MDS narrative reports, (2) careful study and analysis of the manufacturer's maintenance and lubrication plans, and (3) on-board discussions with operating personnel during

Table 3-40. MAINTENANCE BURDEN SUMMARY FOR CG-16 AND CG-26 CLASS MAIN LUBE OIL SYSTEMS

APL	Nomenclature	Applicable Ships	Number of Components	SOY	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Component per Operating Year
760010033 760010087	Lube oil purifier	18	36	112.8	3,906	515	4,421	19.6
016160225	Standby lube oil pump	18	36	112.8	710	333	1,043	4.6
057150179	Standby lube oil pump turbine	18	36	112.8	5,338	1,802	7,140	31.6
882260200 882260383	Turbine governor valve	18	36	112.8	2,110	1,013	3,123	13.8
750080084 750260006 750260052 750440006 750440015	Lube oil duplex strainer	18	36	112.8	1,391	1,451	2,842	12.6

Table 3-41. PARTS-USAGE SUMMARY FOR THE CG-16 AND CG-26 CLASS MAIN LUBE OIL SYSTEM

Part Identification		Cost per Unit (Dollars)	Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of Ships Reported
NSN	Nomenclature						
Lube Oil Purifier, APLs 760010033 and 760010087							
9Z-3110-00-100-2419 1HM3110-00-991-0901NT	Spindle ball bearing	10	2	72	615	854	18
9C-4330-00-028-3911	Bowl boss sleeve	8	1	36	189	525	18
1H-3010-00-600-6789	Spindle flexible coupling	1	1	36	188	522	18
1HM3110-00-991-0896NT	Idler pulley ball bearing	8	2	72	282	392	17
9C-4330-00-218-5938	Spindle	40	1	36	132	367	18
9C-3030-00-270-8356	Flat belt	5	1	36	120	333	18
9C-4330-00-218-5965	Pump rotary seal	23	1	36	118	328	18
9Z-5360-00-292-4140	Drag spring	1	1	36	101	281	18
9C-4330-00-534-5322	Bearing pulley cap assembly	33	1	36	79	219	18
9C-4330-00-368-5782	Spindle bearing sleeve	30	1	36	52	144	16
1HM4420-00-469-1080	Felt bearing oil filter	<1	1	36	52	144	16
2HH4330-00-218-5956	Bowl assembly	2,150	1	36	28	78	11
Steam Turbine for Lube Oil Service Pump, APL 057150179							
1HM2010-00-399-3455	Inboard bearing	120	1	36	54	150	16
1HM2010-00-399-3456	Pinion end bearing	67	1	36	53	147	15
Governor Valve for Lube Oil Standby Service Pump, APL 882260200							
9C-4820-00-036-1554	Diaphragm	2	2	72	204	283	14
9C-4320-00-367-1453	Liner	8	1	36	44	122	13
9C-4820-00-909-3134	Valve disk	27	1	36	36	100	11

ship visits, it has been concluded that spindle bearing failures are attributed primarily to inadequate lubrication.

Other possible causes for individual failures include the following:

- Dirt contamination of the lubricating oil that is applied to the spindle bearings
- Misalignment, incorrect fit-up, or distortion of the bearing housing during renewal installation
- Excessive radial loads arising from mechanical unbalance of the purifier bowl

It is not possible to state specifically which failures can be attributed to the above causes; however, there is strong evidence to support the conclusion that inadequate lubrication is the root cause of most failures in the spindle bearing assembly. Whenever the purifier is in operation, it must be periodically lubricated by an operator. The use of this mode has been confirmed by NAVSEC technical personnel. Further, the operator must be aware that (1) lubricating oil must be applied hourly to the spindle bearings, but only when the purifier is operating, and that (2) a dirty felt filter at the top of the bearing pulley cap assembly can prevent the flow of lubricating oil to the spindle bearings. In addition, the operator must be aware of the importance of the bearing seal ring within the outer face of the bearing pulley cap assembly. The operator must be aware that it is necessary to replace this seal if the bearing pulley cap assembly is removed for any reason, and the operator must know of the existence of the oil access holes in the cap assembly and of the importance of keeping these holes unclogged.

On the basis of visits to two ships of the DDG-37 Class which have purifiers identical to those of the CG-16 and CG-26 Classes, it is known that not all ship personnel are fully aware of these purifier details. Since the reported usage of related parts appears low, there is a basis for doubt that class-wide awareness of purifier details exists. For example, parts-usage data indicate that only 16 of 18 CG-16 and CG-26 Class ships requisitioned felt bearing-oil filter replacements (NSN 1HM4420-00-469-1080), for a grand total of 52. In other words, there is no indication that these filters have ever been changed on two ships. Considering both the CG-16 and CG-26 Classes, the average time between felt bearing oil filter replacements was about four purifier-years, which shows the filters are not changed very often. In addition, there is a possibility that some CG-16 and CG-26 Class ship personnel may not know of the manufacturer's intended plan for lubricating the purifier spindle bearings, since existing PMS requirements do not give attention to those bearings.

A review of current PMS requirements for the CG-16 and CG-26 Class lube oil purifiers has shown that no current requirement exists on any maintenance requirement card (MRC) to do any of the following:

- Lubricate the spindle bearing assembly
- Clean oil passages in the bearing pulley cap assembly

- Check the felt bearing-oil filter for cleanliness and renew if necessary.

One way of ensuring that the spindle bearing is lubricated is to require that the bearing lubrication be recorded hourly on the main engine log (when the purifier is operating) and to add requirements to purifier MRCs or develop new MRCs to incorporate those actions.

During assembly of the data for table 3-41 it was established that five CG-16 Class ships are reporting usage of spindle bearings against two different identifying numbers: NSN 1HM3110-00-991-0901 NT and NSN 9Z3110-00-100-2419. Technical personnel at SPCC, Mechanicsburg, Pennsylvania, have advised that the former number is correct, while the latter number is obsolete and does not appear on any authorized allowance parts list (APL) for lube oil purifiers. NAVSEC technical personnel have advised that these spindle bearings should be replaced in pairs, not singly, to provide for proper load distribution and to ensure equivalent clearances and bearing cleanliness. This replacement practice is not currently required; existing usage data show that odd numbers of bearings are being placed on order, as well as even numbers, which suggests the occurrence of single replacements. Moreover, the allowance parts list for the CG-16 and CG-26 Class lube oil purifier (APLs 760010033 and 760010087) lists a quantity of "2 each" for the spindle bearing (NSN 1HM3110-00-991-0901 NT) rather than "1 pair". A change in the APL to show the latter designation would better reflect the intention of replacing matched pairs of ball bearings rather than single bearings.

Table 3-41 indicates that spindle flexible couplings (NSN 1H 3010-00-600-6789) are ranked third as a high-usage part on CG-16 and CG-26 Class lube oil purifiers. Spindle flexible couplings are specifically designed (1) to absorb vibration caused by out-of-balance conditions in the purifier bowl, and (2) to provide a point of failure if the spindle ball bearings should seize. Thus a limited amount of replacement is normally expected. In addition, when a high rate of failure caused by seizing of the spindle ball bearings exists, there is a direct inflation of the flexible coupling failure rate. However, it appears that a probable additional cause of failure is improper lubrication of the spindle ball bearing assemblies. Some ship's personnel may be applying lubrication to these bearings while the purifier is not operating. Under these circumstances, the lubricating oil runs down onto the flexible coupling, contaminating the coupling and causing it to tear prematurely.

The uncertainty regarding purifier lubrication practices within the CG-16 and CG-26 Classes raises the possibility that some flexible couplings are probably always immersed in lubricating oil, although the manufacturer warns against this practice in NAVSHIPS Technical Manual 0945-003-6010 (page 6-1). A possibility also exists that torn pieces of this neoprene coupling may clog the felt filter in the groove of the bearing pulley cap. If this felt filter has been removed and not replaced, small pieces of torn neoprene also may enter and clog the four 3/32-inch diameter oil passage holes discussed previously.

In summary, the high-usage rate for these couplings is explainable and understandable, and it should decrease once the manufacturer's lubrication instructions are followed more closely throughout the CG-16 and CG-26 Classes.

Idler Pulley Ball Bearings

It is believed that the idler pulley ball bearings, like the spindle bearings, have been failing primarily as a result of inadequate lubrication. The manufacturer provides (on page 6-1 of NAVSHIPS Technical Manual 0945-003-6010) the following lubrication guidance for these bearings:

"Idler Pulley:

(a) Use the same oil as for the spindle bearing assembly.

(b) Oil only when the idler is running.

(c) Put a few drops of oil in the idler pulley cap opening every two or three hours."

A review of current PMS requirements shows that there is no current requirement to perform all of the lubrication procedures recommended by the manufacturer. Seizure of these bearings should decrease if the manufacturer's lubrication instructions are followed more closely. This could be accomplished by requiring that the idler pulley bearings be lubricated and the lubrication recorded on the purifier log every two hours.

Pump Seals

The purifier pump rotary seal (NSN 9C-4330-00-218-5965) is a bellows type shaft seal that is equipped with an internal carbon ring. The seal is manufactured by the John Crane Packing Company of Chicago, Illinois. The manufacturer cautions that the seals must be handled with considerable care during installation. If misaligned or dropped, the carbon seals could crack, thus ruining the seal and necessitating another replacement. Both the MDS narratives and the parts-usage data confirm that CG-16 and CG-26 Class ships frequently replace these seals; discussions with ship personnel indicate that unacceptable loss of lube oil prompts replacement at the slightest evidence of leakage.

Drag Spring, Bowl Boss Sleeves, and Purifier Bowl

The excessive wear experienced by drag springs and bowl boss sleeves, as well as vibration of the purifier bowl, is directly related to ignoring the manufacturer's recommended maintenance procedure set forth on page 4-20 of NAVSHIPS Technical Manual 0945-003-6010. This procedure specifically calls for the following maintenance actions:

- Cleaning of the purifier bowl every time the centrifuge is stopped
- Removal, washing, and inspection of the drag bushing once a week

- Renewal of the drag bushing whenever it is worn as much as 1/16-inch in diameter
- Renewal of the bowl boss sleeve when it is worn 3/64-inch in diameter or is badly scored

Existing PMS maintenance requirement cards do not achieve these ends; thus a number of additions and revisions to these cards are recommended. These changes involve formal scheduling of bowl cleaning and checks on the bowl sleeve. Checks of the drag bushing and drag spring are also introduced. The purpose of these changes is to fill the gaps in the maintenance procedure.

Purifier Bowls and Covers

Damage to lube oil purifier bowls and covers is usually the final incident in a series of related events that result from marginal operational and maintenance practices. Inadequate lubrication of spindle and idler bearings and excessive dirt in the purifier bowl initiate the process. These problems are followed by excessive heat buildup in the bearings and excessive wear of the drag bushing and bowl boss sleeve. Then the added clearances in the drag assembly allow increased eccentricity of the dirty spinning purifier bowl. This situation becomes progressively worse, until finally the spindle bearings become so hot that they seize. The idler bearing pulley then shears away from the flexible coupling; at that point, the purifier bowl assembly is spinning freely and eccentrically. Eventually, the bowl spins to a stop and, in doing so, it may strike the bowl cover and damage both itself and the cover. Clearly, the solution to this problem is found by carefully observing the manufacturer's lubrication and maintenance guidance, particularly with respect to frequent cleaning of the purifier bowls and hourly lubrication of spindle bearings.

Training

The lube oil purifiers will provide reliable service throughout the extended operating cycle if they are adequately maintained. However, the preceding discussions have shown that ships' forces do not generally follow the purifier manufacturers' lubrication recommendations as specified in the equipment technical manuals. Whether this has resulted from lack of familiarity with the technical manuals or from insufficient training is not known. Greater emphasis in the Navy lube oil purifier courses on adhering to the manufacturers' lubrication recommendations should result in more reliable purifier operation and reduced consumption of maintenance resources.

BOH and ROH Requirements

The DDEOC requirements for BOH and the repair profiles for both the CG-16 and CG-26 Class ships recommend class B overhauls of the lube oil purifiers during BOH and at subsequent ROHs. Class B overhauls at BOH are considered necessary to return the lube oil purifiers to a satisfactory

operating condition. If the recommendations of this analysis are implemented, less corrective maintenance should be required in the future. Also, overhauls at ROH should have to be performed only as a result of POT&I. A run-to-failure policy is appropriate for the intracycle periods; necessary repairs should be performed generally by ship's force with some IMA assistance.

3.11.1.3 Recommendations

The following maintenance actions are recommended for inclusion in the DDEOC Program:

- The lube oil purifiers should be overhauled by the depot level repair facility at BOH in accordance with TRS 0262-086-604.
- A qualified task should be prepared for depot level accomplishment of class C repairs to the lube oil purifiers at ROH on the basis of POT&I results and the CSMP. If overhauls are determined to be necessary, they should be accomplished in accordance with the TRS.

The following actions are recommended to correct the current maintenance problems of CG-16 and CG-26 Class lube oil purifiers:

- A 1200 psi Steam Propulsion Improvement Project advisory should be issued as soon as possible to call attention to the manufacturer's hourly lubrication requirements for lube oil purifiers. In addition, the engineering operational procedure for CG-16 and CG-26 Class lube oil purifiers (as set forth in the Engineering Operational Sequencing System) should be revised to require a daily check of the felt filter within the bearing pulley cap, as well as lubrication of spindle bearings every hour and lubrication of idler pulley bearings every two hours. The EOSS should also call attention to the requirement that purifier bowls should be cleaned every time the purifier is stopped (and not less than once a watch). The main engine log should be revised to show that the spindle bearing was lubricated once an hour and the idler pulley bearing lubricated once every two hours. Adherence to the manufacturer's lubrication recommendations should be emphasized in the Navy's lube oil purifier courses.
- PMS maintenance index page E-11/65-96 should be revised to incorporate the following:
  - Add requirements to lubricate spindle bearing assemblies and idler pulley bearings (MRC 96K78XN)
  - Formally schedule cleaning of the purifier bowl and dimensional checks on the bowl boss sleeve (new MRC)
  - Formally schedule cleaning of oil passages in the bearing pulley cap assembly (new MRC)
  - Check the drag bushings more frequently, as recommended by the manufacturer (MRC 96K78ZN)

.. Inspect the purifier more frequently and add a check on the lube oil passages and the felt filter in the bearing pulley cap assembly (MRC 96K78YN)

- Place a warning sign on the top of the belt guard of each lube oil purifier to call attention to the requirements for lubricating the spindle bearing once an hour and lubricating the idler pulley bearing every two hours during operation.
- Advise CG-16 and CG-26 Class ships that spindle bearings should be replaced in pairs, not singly, and that the allowance parts list for lube oil purifiers for the CG-16 and CG-26 Classes should be changed to indicate that the spindle bearings (NSN 1HM3110-00-991-0901 NT) are issued in pairs, not "2 each".

3.11.2 Lube Oil Standby Service Pumps (APL 016160225)

3.11.2.1 Background

All ships of the CG-16 and CG-26 Classes are equipped with two turbine-driven lube oil standby service pumps manufactured by the DeLaval Steam Turbine Company, Trenton, New Jersey. The pump ends of the standby service pumps have been reliable and were not selected for analysis. However, the steam turbine ends and their related Leslie governors are significant sources of man-hour burdens for the main lube oil system. The turbine ends have been grouped by component rather than by APL number since all are of the same design. Table 3-40 shows that 31.6 maintenance man-hours per component per operating year for the turbine end and 13.8 man-hours for the governor valves have been required. Analysis of MDS narrative reports and parts-usage data identified two significant mechanical problems associated with these turbine ends:

- The Leslie turbine governors (APLs 882260200 and 882260383) operate erratically.
- Bearings in the turbine transmisison are failing.

These problems were confirmed by a review of CASREP data. Of the 14 standby lube oil pump CASREPs for which the causes were identified, seven CASREPs were casualties to the drive train, five were for Leslie regulator failures, and two CASREPs were for bearing failures.

3.11.2.2 Discussion

Leslie Governor Problems

Erratic operation of the Leslie governors was reported a total of 51 times by 15 of the 18 ships of the CG-16 and CG-26 Classes; it is believed that this problem is related to incorrect or inadequate maintenance and possibly to a lack of knowledge of detailed Leslie adjustment instructions. The manufacturer's instructions point out that sluggishness in operation can be caused by dirt or foreign matter carried with the steam into the governor and auxiliary pilots, interfering with movement of the working parts.

Discussions with fleet personnel during preparation of the DDG-37 Class systems maintenance analyses disclosed the existence of two Leslie Company drawings that are vital to performing proper maintenance on these governors. The drawings are generally known to those fleet personnel who have worked in the destroyer tender repair shops. The technical manuals for some equipments utilizing Leslie governors will occasionally be found to contain the drawings; however, not all ships employing Leslie governors have copies of these drawings. On one of the two DDG-37 Class ships visited, there was no knowledge of the drawings, while such knowledge existed on the second ship only because one of the petty officers had attended the Leslie Company training course on governors and had used the drawings while he was assigned to a tender. The CG-16 and CG-26 Classes have the same Leslie regulator as the DDG-37 Class; it is very likely that the same lack of knowledge of the Leslie drawings exists on the ships of the CG-16 and CG-26 Classes as on the DDG-37 Class.

The two Leslie Company drawings are No. 1278F, alt. 3, 29 January 1948, and No. 2838F, alt. 1, 20 June 1952. The first drawing provides maintenance instructions for top caps of the internal pilot-operated reducing valves, pump governors, and temperature regulators. The second drawing shows permissible permanent set limits for the diaphragms of Leslie pump governors. These drawings do not appear in NAVSHIPS Technical Manual 347-2336. According to Leslie personnel, failure to observe the critical dimensions shown in Leslie drawing No. 1278F can cause erratic operation of Leslie governors. Attention is also directed to the number of replacements of governor valve diaphragms (NSN 9C-4820-00-036-1554), shown in table 3-41. Leslie drawing No. 2838F shows that a considerable permanent set in these diaphragms is permissible; this guidance may aid in reducing the number of replacements, since it is possible that many diaphragms have been replaced unnecessarily.

There is no positive evidence in the MDS narrative reports that the reported erratic operation of Leslie governors is caused by either dirt in these units or failure to follow these drawings. However, it is well known that Leslie governors that are overhauled by following the manufacturer's instructions and drawings rarely operate erratically. Therefore, it is engineering judgment that cleanliness and proper dimensional settings within the governor are the key to improving the erratic performance reported 51 times in the narrative reports. Moreover, from review of the existing PMS documents that apply to the Leslie governor (i.e., MIP E-9/78-37 and MRC 94 E85 MN) it also appears that the existence of the Leslie drawings may have been unknown to those who prepared the PMS documents; accordingly, these documents require attention. Specifically, the maintenance requirement card (MRC) should be revised to provide reference to the Leslie Company drawings, as well as to include information on the proper cleaning solvent to be used on the governors.

Transmission Bearing Problem

The replacement of bearings in the transmissions of standby lube oil pumps is a widespread problem. As noted in table 3-41, inboard bearings (NIIN 399-3455) were replaced 54 times on 16 ships, and pinion bearings

(NIIN 399-3456) were replaced 53 times on 15 ships. An effort was made to isolate the cause or causes of these replacements by analysis of the MDS narratives and by discussions with ship operating personnel during ship visits. In neither of these areas was a positive cause clearly identified. Thus it is only possible to speculate on the underlying cause, which is most probably loss of lubrication. In this regard, it appears that there is no established procedure for assuring proper oil flow through all installed oil passageways to the bearings of the turbine transmission. Since the turbine transmission is equipped with a self-contained, closed lubrication system, there is no way to determine if lube oil is actually passing through each passageway to its intended bearing. Consequently, a bearing could be starved for lubricating oil, although installed pressure and temperature gauges indicate that conditions are otherwise normal. Subsequent observation of a temperature rise in the oil may occur only after bearing failure.

To check out the oil passageways, it would be necessary to disassemble the transmission completely. Clearly, this minute inspection of oil passageways is feasible only during major overhaul of the lube oil standby service pump turbine. To preclude the loss of lubrication to these turbine transmission bearings during the extended operating cycle, the oil passageways should be checked for freedom from constriction during the baseline overhaul and also during each subsequent regular overhaul.

BOH and ROH Requirements

The review of experience of the standby lube oil pumps justifies a class B overhaul of the turbine and transmission at BOH and each subsequent ROH to reduce the number of bearing replacements (especially those resulting from blocked oil passages) and to ensure proper operation of the standby lube oil pumps throughout the extended operating cycle. Overhaul of the pump end of the standby lube oil pump is not justified on the basis of the review of experience; this overhaul should be removed from the DDEOC repair requirements for BOH.

3.11.2.3 Recommendations

On the basis of the previous discussion, the following actions are recommended:

- Have the depot overhaul the standby lube oil pump turbines at BOH in accordance with TRS 0262-086-625.
- Delete the requirement from the DDEOC repair requirements for BOH to overhaul the pump ends of the standby lube oil pumps at BOH.
- Prepare an engineered task for the CMP for depot level accomplishment of class B overhaul of the standby lube oil pump turbines in accordance with TRS 0262-086-625 at each ROH.
- Advise all CG-16 and CG-26 Class ships of the existence of Leslie Company drawings No. 1278F, alt. 3, and No. 2838, alt. 1, for

use in maintenance of Leslie governors, and revise PMS documents MIP E-9/78-37 and MRC 94 E85 MN to reflect the guidance contained in these drawings.

- Add a specific requirement to TRS 0262-086-625 to check the oil passageways to the bearings of the turbine transmission for freedom from constriction.

3.11.3 Lube Oil Duplex Strainers (APLs 750080084, 750260006, 750260052, 750440006, and 750440015)

3.11.3.1 Background

Each CG-16 and CG-26 Class ship is equipped with two five-inch lube oil duplex strainers. These units strain and filter foreign matter from the lubricating oil before it enters the bearings and oil sprays. The construction of the duplex strainer permits diversion of lubricating oil flow through either of two chambers. Installed in each chamber is a removable wire mesh strainer basket, or "sediment strainer element" as it is designated on the allowance parts lists. Duplex strainers, identified by APLs 750080084 and 750440015, are equipped with removable arrays of bar magnets inserted within the baskets to further improve straining and to permit easier access for removal of ferrous particles.

3.11.3.2 Discussion

Table 3-40 shows that duplex strainers are responsible for an average maintenance burden of 12.6 man-hours per component per operating year. In view of the continuous use of these strainers while the ship is underway, this burden is not excessive and is not indicative of any major problem. Further, MDS narrative reports revealed that 36 percent of the reported effort has actually been devoted to the maintenance of safety covers over the duplex strainers; thus only 64 percent of the maintenance burden is attributed to the strainers themselves. Only two CASREPs were submitted on duplex strainers during the data period 1 January 1972 through 31 August 1978. Parts-usage analysis did not reveal significant usage of any repair items. Further discussion of the duplex strainers is not warranted and a continuation of the present maintenance policy of run-to-failure is appropriate. The DDEOC repair requirements for BOH recommendation to overhaul the lube oil duplex strainers has not been justified by this review of experience and should be eliminated.

3.11.3.3 Recommendations

The following actions are recommended:

- Delete the overhaul of the lube oil duplex strainers from the DDEOC repair requirements for BOH

- Make repairs to strainers and strainer shields during BOH and ROH on the basis of POT&I results and the CSMP

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following conclusions resulted from this review of experience:

- The maintenance histories of CG-16 and CG-26 Class 1200 psi propulsion plant equipments were similar to those of identical or functionally similar equipments installed in DDG-37 and FF-1052 Class ships.
- The following equipments will require class B overhaul during baseline overhaul: fuel oil burners, soot blower heads, the entire ACC/FWC/MFPC system, three of six main feed pumps and turbines, the Worthington and Terry main feed pump turbine steam admission valves and servomotors, two of four fuel oil service pumps, the fuel pressure regulating valves, the lube oil purifiers, and the standby lube oil pump turbines. All the other equipment analyzed in this report should be repaired as shown to be necessary by POT&I and each ship's CSMP.
- Scheduled restorative maintenance will be required during the operating cycle on the following equipments: boiler-skirt casings, ACC/FWC/MFPC, forced draft blowers, and the forced draft blower turbine exhaust and relief valves.
- Major improvements are required to boilers and the main lube oil system to ensure reliable operation and improved performance during the operating cycle. Most of these improvements exist in the form of shipalts; however, some improvements must be explicitly defined and authorized. NAVSEA will require the support of the TYCOMs and NAVSEC to define and implement these improvements.
- A series of changes, deletions, and additions to PMS will improve the routine preventive maintenance of propulsion plant equipments during the operating cycle. These modifications will be required for the following equipments: safety valves and soot blowers, forced draft blower turbine exhaust and relief valves, main feed pump turbine steam admission valve, auxiliary circulating pump, lube oil purifiers and standby lube oil pump turbines.

- Extensive improvements to the integrated logistics support (ILS) of the following systems will be required to effectively implement the recommended maintenance policies for propulsion plant equipments: boilers, ACC/FWC/MFPC, combustion air, feed and condensate, circulating and cooling, fuel oil service, and main lube oil. Improvements to the ILS include POT&I revisions; development and implementation of a management system to assist readiness support groups and similar activities in coordinating their work, quality assurance, contracts, and specification writing; changes to the Engineering Operational Sequencing System (EOSS); deletion of routine overhaul of propulsion plant equipments from the DDEOC repair requirements for BOH; and issuance of 1200 psi improvement program advisories for specific equipments.
- This analysis has, as in the FF-1052 and DDG-37 analyses, determined that IMA capabilities to calibrate and repair ACC/FWC/MFPC systems are inadequate and should be improved.

4.2 RECOMMENDATIONS

Recommendations for corrective action and improvement for 1200 psi propulsion plant equipments are categorized as follows:

- Baseline overhaul requirements
- Intracycle requirements
- Regular overhaul requirements
- Reliability and maintainability improvements
- PMS changes
- Integrated logistics support improvements
- Industrial facility improvements
- IMA improvements

Table 4-1 summarizes the recommendations resulting from the 1200 psi propulsion plant analysis. The column headings are explained as follows:

- Component - the applicable equipment
- No. - the recommendation number; listed to allow tracking
- Recommendation/Maintenance Action - the improvement or maintenance requirement identified necessary by the analysis
- Level of Maintenance - D = depot, I = IMA, O = organizational (ship's force)
- Periodicity of Maintenance - when the prescribed maintenance should be performed

- **Engineered or Qualified - E (= engineered) the maintenance action that is to be performed is explicitly defined and scheduled on a regular basis, or Q (= qualified) if the maintenance is only generally defined or considered to be a repair reservation**
- **Section Reference - the section of this report that discusses the maintenance experience of the component and provides a rationale for the recommended action**

Table 4-1. SUMMARY OF RECOMMENDED ACTIONS FOR 1200 PSI PROPULSION PLANTS ON CG-16 AND CG-26 CLASS SHIPS

Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		BOH and ROH Requirements				
Boilers	1	Accomplish shipalts CG-16-1184D and CG-26-364D, boiler casing steam smothering supply, during ROH	D	BOH	-	3.2.2
	2	Make the following boiler repairs:				
		. Replace all missing or stripped boiler casing studs, bolts, and dogs	D	BOH,ROH	Q	3.2.2
		. Straighten and regasket all inner and outer casing access doors as determined necessary by air test	D	BOH,ROH	Q	3.2.2
		. Renew boiler casing skirts	D	BOH	E	3.2.2
		. Repair deteriorated areas of casing as determined necessary by pre-overhaul test and inspection, paying particular attention to the areas listed in the (revised) POT&I	D	BOH,ROH	Q	3.2.2
		. Repair boiler casing skirts as determined necessary through air test and inspection	D	ROH	Q	3.2.2
	3	Renew all castable refractory and burner tiles	D	BOH,ROH	E	3.2.3
	4	Renew other refractory as determined necessary by inspection. If total refractory replacement is required, accomplish shipalts CG-16-1133D/CG-26-315D, shockhardened brickwork	D	BOH,ROH	Q	3.2.3
	5	Free up any sliding feet (by cleaning, flushing, and greasing) where a positive indication of movement is not present	D	BOH,ROH	Q	3.2.4
	6	Accomplish the following shipalts	D	BOH	-	3.2.5
		. Morpholine injection, CG-16-1086K and CG-26-446D				
		. Demineralizer, CG-16-1244K and CG-26-423K				
		. Morpholine deficiencies, CG-16-1276D				
		. Dissolved oxygen measuring system, CG-16-1192K and CG-26-464K				
		. Superheater safe ends, CG-16-1170D				
		. CE boiler superheater, CG-26-365D				
	7	Accomplish the following:				
		. Closely examine the FW boiler superheater inlet pass for external thinning and the first four or five main generating bank tube rows for external thinning and/or internal pitting, referencing POT&I test procedure 221F1010130	D	BOH	E	3.2.5
		. Renew defective steam drum mounting studs and steam drum internal fittings. Clean the steam drum internals.	D	BOH,ROH	E	3.2.5
		. Renew steam drum and water drum insulation and water drum insulation retainer	D	BOH,ROH	E	3.2.5
		. Resurface seating surfaces on manhole covers and in drums	D	BOH,ROH	E	3.2.5
		. Radius and NDT all drum and header nozzles	D	BOH,ROH	E	3.2.5
		. Hydrostatically test, NDT, and repair the desuper-heater inlet and outlet nozzles	D	BOH,ROH	E	3.2.5
		. Conduct a BTIU inspection and remove and analyze rear wall, sidewall, generating, superheater, and screen wall tubes as determined necessary	D	BOH,ROH	Q	3.2.5
	8	Remove all superheater, economizer, and sidewall and rear wall header hand hole plates. Inspect the gasket seating surface and repair them as necessary. Re-install all hand hole nuts with an effective anti-seize compound.	D	BOH,ROH	E	3.2.6
Boiler Blow Systems	9	Install the following shipalts				
		. Redesigned boiler blow systems, CG-16-1261K and CG-26-441K	D	BOH	-	3.2.7
		. HP drain orifices, CG-16-1231D and CG-26-271K				
	10	Ultrasonically test the bottom and surface blow piping and HP drain piping. Repair or replace the	D	ROH	Q	3.2.7

Table 4-1 (Continued)						
Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		BOH and ROH Requirements (continued)				
Boiler Blow Systems (cont.)	10	*piping and valves as found necessary* by the ultrasonic tests, the pre-overhaul hydrostatic test, the POT&I and the CSMP.				
Uptake and Stacks	11	Routinely inspect stack drains for clogging and deterioration and clean and repair them as necessary	D	BOH,ROH	Q	3.2.8
	12	Routinely inspect the stack and uptakes for deterioration and clean and repair them as necessary	D	BOH,ROH	Q	3.2.8
	13	Inspect the expansion joints and repair or replace them as necessary	D	BOH,ROH	Q	3.2.8
Valves	14	Repair only those valves that are known to leak through the seat or seal ring based upon ship's force experience, the POT&I, and the CSMP	D	BOH,ROH	Q	3.2.9
Burners	15	Overhaul the burner housings and air registers in accordance with TRS 0221-086-628 (B&W), 0221-086-629 (CG-16 Class Todd), or 0221-086-633 (CG-26 Class Todd), and test them using the 1200 psi test procedure. Make other repairs to burners and shut-off devices as shown to be necessary by POT&I, CSMP, or fireside inspection.	D	BOH,ROH	E	3.2.10
	16	*Accomplish the following shipalts*				
		. VP atomizer burner, CG-16-1094K and CG-26-242K	D	BOH	-	3.2.10
		. Improve fuel oil system remote shutdown, CG-16-1113K and CG-26-231K	D	BOH	-	3.2.10
	17	Consider installing the following shipalts:				
		. Replace/relocate fuel oil micrometer valves, CG-16-1271D and CG-26-455D	D	BOH	-	3.2.10
		. Relocate burner light-off door, CG-16-1279D and CG-26-460D	D	BOH	-	3.2.10
Safety Valves	18	Remove and inspect the safety valves and repair them as shown to be necessary by disassembly and inspection, the POT&I, and the CSMP.	D	BOH,ROH	Q	3.2.11
Soot Blowers	19	Accomplish shipalts CG-16-0145D and CG-26-096D, boiler soot blower piping modifications on CG-16, -26, and -27.	D	BOH	-	3.2.12
	20	Ultrasonically test soot blower heads and repair or replace them as necessary	D	BOH,ROH	Q	3.2.12
	21	Overhaul the soot blower heads in accordance with TRS 0221-086-624, 0221-086-625, 0221-086-626, or 0221-086-634. Set the blowing arcs and pressures and perform an operational test.	D	BOH,ROH	E	3.2.12
Yarway Gauge Glasses	22	Examine all Yarway gauge glass cap screws and body threads for damage. Replace damaged cap screws and plug weld and retap body threads. Examine (IMA level) the spring cone washer assemblies for cracking and replace defective assemblies.	D,I	BOH,ROH	E	3.2.13
	23	Accomplish shipalts CG-16-1144K and CG-26-318K, install improved remote boiler water level indicators	D	BOH	-	3.2.13
Economizer	24	Remove a row of B&W boiler economizer tubes for analysis during the pre-overhaul inspection. The row to be removed should be determined by a review of ship's records. If no unique history is evident, failure reports indicate that rows G, H, T, or U have experienced the most failures and should be sampled. Authorize economizer repairs as found necessary based upon the analysis. FW and CE boilers should have economizer tubes removed for analysis only when indicated necessary by the pre-overhaul inspection.	D	BOH,ROH	Q	3.2.14
ACC/FWC/MFPC	26	Ensure that shipalts CG-16-1090D and CG-26-347D, signal line pressure gauges, are installed.	D	BOH	-	3.3.3
	27	Accomplish shipalts CG-16-1085K and CG-26-226K, oil-free LP air compressors. Flush the control lines thoroughly to eliminate previous oil contamination.	D	BOH	E	3.3.4

Table 4-1 (Continued)

Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
BOH and ROH Requirements (continued)						
ACC/FWC/MFPC (cont.)	28	Standardize the ACC/FWC/MFPC systems by installing shipalts CG-16-1278K, CG-26-235K, CG-26-3490D, and CG-26-500K	D	BOH	-	3.3.5
	29	Implement on-line verification by authorizing and installing the updating and standardizing shipalts currently being processed within NAVSEA PMS-301 and supply all CG-16 and CG-26 Class ships with the OLV documents.	NAVSEA	BOH	-	3.3.6
	30	Overhaul the ACC/FWC/MFPC systems in accordance with the TRS (see section) or to class B standards if a TRS is not available.	D	BOH,ROH	E	3.3.7
	31	Calibrate all ACC/FWC/MFPC gauges and indicators and inspect and repair all tubing and fittings	D	BOH,ROH	E	3.3.7
HP and LP Turbines	32	Accomplish depot level class C repairs on the HP and LP turbines as shown to be necessary by POT&I and the CSMP. Repair actions that may be expected include renewal of gland packing, repair of throttle valves, and adjustment of throttle linkages.	D	BOH,ROH	Q	3.4.3
	33	Accomplish the following shipalts . CG-16-1007, -1328, -179, -1189, -1204, -1340 . CG-26-124, -501, -155	D	BOH	-	3.4.3
	34	Accomplish repairs of the HP and LP turbine labyrinth packing, nozzle blocks, and journal bearings as necessary.	D	ROH	Q	3.4.3
	35	Bench-test propulsion turbine sentinel pressure-relief	I,D	ROH	E	3.4.3
Propulsion Shafting	36	Perform bearing reaction tests on line shaft spring bearings in accordance with MRC R-6 on MIP E-12/139-B7 and add this task to the DDEOC repair requirements for BOH	D	BOH,ROH	E	3.5.3
	37	Renew inflatable shaft seals, face seals, and garter springs in accordance with MRC R-5 on MIP E-12/139-B7 and add this task to the DDEOC repair requirements for BOH	D	BOH,ROH	E	3.5.3
	38	Measure stern tubes and strut bearing clearances and inspect condition of shaft coverings in accordance with MRC R-4 on MIP E-12/139-B7 and add this task to the DDEOC repair requirements for BOH.	D	BOH,ROH	E	3.5.3
Combustion Air	39	Make class C repairs to forced draft blowers on the basis of pre-overhaul inspection results. Anticipate that three of eight of a ship's forced draft blowers may require class B overhauls.				
Condensers and Air Ejectors	40	Ultrasonically test the main condenser shells in accordance with MRC C-2 on MIP E-4/189-B7 or MRC C-2 on MIP E-4/179-18.	D	BOH,ROH	E	3.7.1
	41	Test condenser relief valves in accordance with either MRC C-2 on MIP E-4/188-B7 or MRC A-10 on MIP E-4/188-38 as applicable.	I	BOH,ROH	E	3.7.2
	42	Ultrasonically inspect the auxiliary condenser shell in accordance with MRC C-1 on MIP E-4/180-38 or MRC C-1 on MIP E-4/188-B7.	D	BOH,ROH	E	3.7.2
	43	Accomplish shipalts CG-16-1376D and CG-26-546D to improve the reliability of the auxiliary gland exhaust fans	D	BOH	-	3.7.3
Feed and Condensate	44	Repair the main feed pumps as shown to be necessary by POT&I and each ship's CSMP. Anticipate that three of a ship's six pumps will require overhaul. Accomplish any overhauls in accordance with TRS 0255-086-643, 0255-086-649, or 0255-086-650.	D	BOH,ROH	Q	3.8.2
	45	Repair the main feed pump turbines as shown to be necessary by POT&I and each ship's CSMP. Anticipate that three of a ship's six turbines will require overhaul. Accomplish any overhauls in accordance with TRS 0255-086-652 and 0255-086-661. If a TRS is not	D	BOH,ROH	Q	3.8.2

Table 4-1 (Continued)						
Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
BOH and ROH Requirements						
Feed and Condensate (cont.)	45	available for a specific turbine, overhaul the turbine to class B standards.				
	46	Class B overhaul the Worthington main feed pump turbine steam admission valves and servomotors in conjunction with the installation of shipalts CG-16-1281D and CG-26-463D.	D	BOH	E	3.8.2
	47	Repair the Worthington main feed pump turbine steam admission valves and servomotors as identified by MRC F-13 U-5, the POT&I, and each ship's CSMP.	D	ROH	Q	3.8.2
	48	Class B overhaul the Terry main feed pump turbine steam admission valves and servomotors.	D	BOH	E	3.8.2
	49	Repair the Terry main feed pump turbine steam admission valves and servomotors as identified by MRC F-13 U-5, the POT&I, and each ship's CSMP.	D	ROH	Q	3.8.2
	50	Repair the main feed booster pumps on the basis of POT&I results, PMS inspections, and each ship's CSMP. If overhauls are required, they should be performed in accordance with TRS 0255-086-647.	O,I	BOH,ROH	Q	3.8.2
	51	Repair the main feed booster pump turbines on the basis of POT&I results, PMS inspections, and each ship's CSMP. If overhauls are required, they should be performed in accordance with TRS 0255-086-649 (CG-16 Class only; turbines are not installed on CG-26 Class ships).	D	BOH,ROH	Q	3.8.2
	52	Repair the reserve feed transfer pump vacuum priming pumps on the basis of POT&I results and each ship's CSMP.	O,I	BOH,ROH	Q	3.8.2
	53	Repair the reserve feed transfer pumps on the basis of POT&I results and each ship's CSMP.	O,I	BOH,ROH	Q	3.8.2
	54	Repair the main feed booster pump and reserve feed transfer pump motors on the basis of POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.8.2
	55	Accomplish shipalts CG-16-1213D and CG-26-393D, strengthen DFT shell.	D	BOH	-	3.8.2
	56	Repair the DFTs on the basis of POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.8.2
	57	Repair the main condensate pumps on the basis of POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.8.3
	58	Repair the main condensate pump turbines on the basis of POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.8.3
	59	Repair the auxiliary condenser condensate pumps on the basis of POT&I results and each ship's CSMP.	O	BOH,ROH	Q	3.8.3
	60	Repair the condensate subsystem pump motors on the basis of POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.8.3
Salt Water Circulating System	61	Inspect the main salt water circulating pump prior to BOH in accordance with MRC C-1 on MIP E-5/59-28. Repair the pumps on the basis of the results of that inspection and the results of the POT&I. If it is determined that overhauls are required, they should be performed in accordance with TRS 0256-086-601.	O,D	BOH	Q	3.9.1
	62	Overhaul the main salt water circulating pumps at 10-year intervals in accordance with TRS 0256-086-601.	D	ROH	E	3.9.1
	63	Perform class C repairs on the main salt water circulating pump turbines during BOH unless the main circulating pumps are selected for class B overhauls. In that case, overhaul the turbines in accordance with TRS 0256-086-614.	I,D	BOH	Q	3.9.2
	64	Overhaul the main salt water circulating pump turbines at 10-year intervals in accordance with TRS 0256-086-614.	D	ROH	E	3.9.2
	65	Repair the auxiliary salt water circulating pumps as shown to be necessary by POT&I and CSMP.	D	BOH	-	3.9.3

Table 4-1 (Continued)						
Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		BOH and ROH Requirements				
Fuel Oil Service System	66	Overhaul two of four fuel oil service pumps in accordance with TRS 0261-086-601. Select the pumps on the basis of POT&I results and each ship's CSMP. Make class C repairs to the other two pumps.	O,D	BOH,ROH	Q	3.10.3
	67	Repair the fuel oil service pump turbines on the basis of POT&I results and each ship's CSMP. If overhauls are necessary, they should be accomplished in accordance with TRS 0261-086-600.	D	BOH,ROH	Q	3.10.4
	68	Repair the fuel oil piping in accordance with the DDEOC repair requirements for BOH.	D	BOH	E	3.10.3
	69	Repair the fuel oil piping in accordance with the 1200 psi test and certification manuals.	D	ROH	Q	3.10.4
	70	Repair the CG-16 Class fuel pressure regulating valves on the basis of POT&I results and each ship's CSMP.	D	BOH	-	3.10.5
	71	Overhaul the CG-26 Class fuel pressure regulating valves.	D	BOH,ROH	E	3.10.5
	72	Repair the port and cruising fuel oil service pumps and motors as shown to be necessary by POT&I results and each ship's CSMP.	D	BOH,ROH	Q	3.10.6
	73	Repair the fuel oil duplex strainers as shown to be necessary by the PMS inspections and each ship's CSMP.	I	BOH,ROH	Q	3.10.7
Main Lube Oil System	74	Overhaul the lube oil purifiers in accordance with TRS 0262-086-604.	D	BOH	E	3.11.1
	75	Make class C repairs to the lube oil purifiers during ROH.	D	ROH	Q	3.11.1
	76	Overhaul the standby lube oil pump turbines in accordance with TRS 0262-086-625.	D	BOH,ROH	E	3.11.2
		Intracycle Maintenance Requirements				
Boilers	77	Inspect the boiler bilge-skirt casing and repair it as shown to be necessary by the inspection and each ship's CSMP.	D	SRA	E	3.2.2
ACC/FWC/MFPC	78	Repair and calibrate the ACC/FWC/MFPC systems as shown to be necessary by the results of a boiler flexibility test conducted in accordance with MRC Q-10 on MIP F-26/126-A7.	D	SRA	Q	3.3.7
Combustion Air	79	Make class C repairs to forced draft blowers. Anticipated repairs will include replacement of labyrinth packing, refurbishment of steam valve, and overhaul of governors.	I	20M	Q	3.6.2
	80	Dress the seats and disks of the forced draft blower turbine exhaust and relief valves.	O,I	18M	E	3.6.2
Feed and Condensate	81	Use MRC F-13 U-17, F-13 C-1, and F-13 C-4 to identify specific main feed pump repairs when less than adequate performance is experienced or when known degradation has occurred.	O	-	-	3.8.2
		Reliability and Maintainability Improvements				
Boilers	82	Install sliding feet movement indicators where not already installed.	I,D	BOH	-	3.2.4
	83	Provide a telltale for boiler sliding feet to give an indication of positive grease flow through the sliding feet. The telltale should be visible from the grease fitting.	D	BOH	-	3.2.4
	84	Regarding boiler lay-up procedures: . Identify the equipment and procedures necessary to implement a forced hot-air boiler lay-up capability in the fleet.		-	-	3.2.5

Table 4-1 (Continued)

Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		Reliability and Maintainability Improvement				
Boilers (cont.)	84	. Investigate a combination hydrazine waterside and forced-hot-air fireside lay-up for boilers layed up for up to six months. . Review fleet experience with the nitrogen lay-up procedures for FW ships and determine its actual effectiveness. . Provide a wet boiler lay-up, in accordance with NSTM chapter 221, between final hydrostatic test and boiler light-off.				
	85	Establish a policy of extending the waterside inspection and cleaning interval on those ships with shipalt-installed morpholine injection systems and ion exchangers. Extension of the waterside inspection and cleaning interval for an individual ship should be based on the results of an inspection performed by a certified boiler inspector three to six months following shipalt installation or BOH, whichever is later.		-	-	3.2.5
	86	Encourage ship's force to make and use a flange alignment pin, as shown in Figure 5-1 of the Repair and Overhaul Technical Manual for Main Boilers (NAVSEA 0951-LP-031-8010).		-	-	3.2.5
	87	TYCOMs should emphasize to IMAs that, whenever possible, welded-in valves should be repaired in-place rather than automatically cut out and repaired in the shop.		-	-	3.2.9
	88	Continue current NAVSECPHILADIV efforts to resolve the carbon build-up problem with the VP burners at low steaming rates and include an extensive shipboard testing period.		-	-	3.2.10
	89	Investigate the feasibility of restoring burner centering-projections by rewelding at the IMA or depot level. Add a note to MRC F-1 R-15 to check the burner projections when inspecting burner barrels. Check the projection dimensions at BOH and ROH and repair as necessary.		-	-	3.2.10
	90	Provide each ship with the new, improved, self-aligning safety valve gag. Make appropriate changes to the safety valve APLs and the technical manuals.		-	-	3.2.11
	91	Mark the Yarway gauge glasses to advise use of only the special Yarway threading set.		-	-	3.2.13
	92	Promulgate a specific torque valve to apply to the cap screws when reassembling Yarway gauge glasses. Advise maintenance personnel to run a nut onto each cap screw all the way to the collar before reassembly to ensure that good threads are available and no false indication of resistance will be encountered because of a damaged thread.		-	-	3.2.13
	93	Cancel shipalts CG-16-1093K and CG-26-241K, install Nucleonic water gauges, and install an additional Barton remote BWLI under shipalts CG-16-1144K and CG-26-318K instead.		-	-	3.2.13
Main Feed Pump Turbine Steam Admission Valve Servomotor	94	Investigate the failures and erratic operation and develop an alteration to correct the problems.		-	-	3.8.2.2
Main Lube Oil System	95	Place a warning sign on the top of the belt guard of each lube oil purifier to call attention to the requirements for lubricating the spindle bearing every hour and the idler pulley bearing every two hours during operation.		-	-	3.11.1
		PMS Changes				
Boiler Safety Valves	96	Change MRC F-1 R-3 of MIPs F-1/33-96, F-1/57-58, F-1/90-47, F-1/122-96, F-1/194-77, and F-1/196-78, which cover testing of safety valves by steam, by adding a sentence to read: "Excessive lifting of safety valves contributes to valve leakage; attempt to accomplish all adjustments within two or three lifts."		-	-	3.2.11

Table 4-1 (Continued)						
Component	**No.**	**Recommendation/Maintenance Action**	**Level of Maintenance**	**Periodicity of Maintenance**	**Engineered or Qualified**	**Section Reference**
		PMS Changes				
Soot Blowers	97	Change MRC F-1 A-2 of all MIPs F-1/XXXX as follows: after step 16, which reads, "Remove pipe plug from test connection," insert "Warning: Do not allow live steam to pressurize test gauge. This could result in rupture of the gauge and possible personnel injury." Change step 1c to read: "Prepare a test pressure gauge with 0 to 600 psi range and 3/8-inch fittings. Make a loop in the gauge hose and charge the loop with water. Install the test gauge in the test connection."		-	-	3.2.12
Combustion Air System	98	Develop a maintenance requirement for ships' forces to dress the seats and discs of the exhaust and relief valves every 18 to 24 months.		-	-	3.6.2
Feed and Condensate	99	Add MRCs F-13 Q-20 and F-13 U-5 (inspection and tests of the steam admission valve) to MIP F-13/84-77.		-	-	3.8.2
Salt Water Circulating System, Auxiliary Circulating Pumps	100	Change the periodicity of PMS inspection A-19 A-1 on MIP A-19/225-18 from "annual" to "as required".		-	-	3.9.3
Main Lube Oil System, Lube Oil Purifiers	101	Revise PMS MIP E-11/65-96 to incorporate the following: . Add requirements to lubricate spindle bearing assemblies and idler pulley bearings (MRC 96K78XN) . Formally schedule cleaning of the purifier bowl as well as dimensional checks on the bowl boss sleeve (new MRC) . Formally schedule cleaning of oil passages in the bearing pulley cap assembly (new MRC) . Check the drag bushings more frequently as recommended by the manufacturer (MRC 96K78ZN) . Inspect the purifier more frequently and add a check on the lube oil passages and the felt filter in the bearing pulley cap assembly (MRC 96K78YN)		-	-	3.11.1
Standby Lube Oil Pump Turbines	102	Advise all CG-16 and CG-26 Class ships of the existence of Leslie Company drawings, No. 1278F, Alt. 3, and No. 2838, Alt. 1, for use in maintenance of Leslie governors, and revise MRC 94-E85-MN on MIP E-9/78-37 to reflect the guidance contained in those drawings.		-	-	3.11.2
		Integrated Logistics Support				
Boilers	103	Revise POT&I sheets for boiler inspection to include specific attention to the areas of recurring air-casing deterioration: . B&W brick pan . B&W sidewall header . B&W rear casing near superheater door . B&W superheater cavity access doors . FW inner-casing access doorframes at front generating tube area below economizer tubes . FW area behind casing joint U-channel covers . FW casing expansion joint beneath the steam drum . CE boiler superheater access doors and frames . Outer rear casing at the water-drum expansion joint . Boiler skirt at bilge boundary on B&W, FW, and CE boilers		-	-	3.2.2
	104	Revise the POT&I sheets to direct specific attention to those areas where recurring refractory failures occur:		-	-	3.2.3

Table 4-1 (Continued)

Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		Integrated Logistics Support				
Boilers (cont.)	104	. Superheater cavity (B&W and FW) . Front wall (B&W and FW) . Superheater support plate (B&W) . Burner tiles (FW and CE) . Brickwork (CE)				
	105	As part of the annual boiler inspection and prior to BOH and ROH, check to ensure that the tools necessary to mechanically clean tubes with air-driven expanding wire brushes are aboard.		-	-	3.2.5
Valves	106	Establish a requirement and a specific procedure for intermediate- and depot-level industrial activities to ensure that changes in valve seal rings are properly documented and that proper spares support is provided after repair.		-	-	3.2.9
Yarway Gauge Glasses	107	Investigate the feasibility and cost-effectiveness of authorizing depot-level industrial activities to disassemble the spring cone washer assemblies and replace the washers only, instead of the complete assembly.		-	-	3.2.13
	108	Add to each ship's allowance, two complete gauge glass assemblies, one per fireroom, to be bulkhead mounted.		-	-	3.2.13
ACC/FWC/MFPC	109	Survey RSGs and other similar organizations to completely define the ILS problems and determine if the problems exist at all IMA coordination centers.		-	-	3.3.2
	110	Develop and implement a management system to assist RSGs and other similar organizations with the coordination of incoming work, contracts, quality assurance, and specification writing.		-	-	3.3.2
	111	Document contractor-performed repairs in the MDS system.		-	-	3.3.2
	112	Establish work center EB13 on all ships to be responsible for ACC/FWC/MFPC maintenance and continue to emphasize staffing each ship with a minimum of one senior petty officer (E-5 or above), with ACC/FWC/MFPC system technician qualifications and experience, as work center supervisor.		-	-	3.3.3
	113	Expand the scope of the ACC/FWC/MFPC maintenance school to provide: . Increased system troubleshooting training . Increased training on fine tuning operational systems These recommendations could be accomplished by expanded use of school ships or a hot plant to complement simulator training.		-	-	3.3.3
	114	Ensure that ships are manned with fully qualified, operationally experienced technicians by adopting a three-stage qualification and certification procedure to be accomplished by the following actions: . Establish an ACC/FWC/MFPC system maintenance technician certification course at the ACC/FWC/MFPC system schools that provide the basic system maintenance training. . Modify the current NEC qualification procedure by creating a new NEC, which would indicate a limited qualification, for award to basic ACC/FWC/MFPC system maintenance school graduates. Reserve the existing NEC, which currently indicates full qualification, for award upon completion of the ACC/FWC/MFPC system maintenance technician certification course.		-	-	3.3.3

Table 4-1 (Continued)

Component	No.	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Engineered or Qualified	Section Reference
		Integrated Logistics Support				
ACC/FWC/MFPC (cont.)	114	. Modify the current procedures for ACC/FWC/MFPC system technician assignment to accomodate the two levels of qualification defined in the first part of this recommendation.				
Combustion Air System	115	Change the engineering operational sequencing system (EOSS) securing procedures to permit the FDB turbine casing low-pressure drain or blow-down lines to remain open at all times at which the turbine is secured.		-	-	3.6.2
	116	Change the EOSS securing procedures to allow the gland seal steam exhaust line to remain open while the turbine is secured and the gland seal condenser exhaust fan to run continuously regardless of the plant's steaming condition.		-	-	3.6.2
Feed and Condensate, Circulating and Cooling Fuel Oil Service	117	Delete the routine overhauls of the following equipments from the DDEOC repair requirements for BOH:		-	-	
		. Main feed pumps and turbines				3.8
		. Main feed booster pumps, turbines, and motors				3.8
		. Reserve feed transfer pumps				3.8
		. Main condensate pumps, turbines, and motors				3.8
		. Auxiliary condenser condensate pumps and motors				3.8
		. Main circulating pumps and turbines				3.9
		. Auxiliary circulating pumps and motors				3.9
		. Fuel oil service pumps and turbines				3.10
		. Port and cruising fuel oil service pumps, motors, and controller				3.10
		. Duplex fuel oil and lube oil strainers				3.10 and 3.11
Main Lube Oil	118	A 1200 psi Steam Propulsion Plant Improvement Program advisory should be issued as soon as possible to call attention to the manufacturer's hourly lubrication requirements for lube oil purifiers. In addition, the EOSS for CG-16 and CG-26 Class lube oil purifiers should be revised to require daily checking of the felt filter within the bearing pulley cap, as well as lubrication of spindle bearings every hour and lubrication of idler pulley bearings every two hours. These documents should also call attention to the requirement that purifier bowls be cleaned every time the purifier is stopped and not less than once a watch. Emphasize adherence to the manufacturer's recommendations for purifier lubrication in the lube oil purifier courses.		-	-	3.11.1
	119	CG-16 and CG-26 Class ships should be advised that spindle bearings should be replaced in pairs, not singly, and the APL for lube oil purifiers changed to indicate that the spindle bearings (NSN 1HH-3110-00-991-0901 NT) are issued in pairs, not two each.		-	-	3.11.2
	120	Add a specific requirement to TRS 0262-086-625 to check the oil passageways to the bearings of the standby lube oil pump turbine transmission for freedom from constriction.		-	-	3.11.2
		IMA Improvement				
ACC/FWC/MFPC	121	Emphasize the upgrading of IMA ACC/FWC/MFPC calibration and repair capabilities by assigning qualified personnel, E-5 or above with ACC/FWC/MFPC training and experience, to be dedicated to provide support to the fleet.		-	-	3.3.3

SOURCES OF INFORMATION

The specific sources of information used as a basis for the system maintenance analysis of the 1200 psi propulsion plants are listed below.

1. Generation IV MDS part and maintenance data for the period 1 January 1970 through 31 December 1977.

2. CASREP narrative summaries for the period 1 January 1972 through 31 August 1978.

3. Technical manuals:

   - NAVSHIPS 351-0685 and 351-0739, Babcock and Wilcox main boilers
   - NAVSEA 0351-067-5000 and 0351-067-5010, Foster Wheeler D-type main boilers
   - NAVSEA 0351-072-8000, Combustion Engineering type V2M main boilers
   - NAVSEA 0951-LP-031-8010, Repair and overhaul main boilers, 1200 psi steam propulsion plant
   - NAVSEA 0951-015-8010, 0951-018-8010, 351-0723, 0951-017-1010, and 351-0707, ACC/FWC/MFPC systems
   - NAVSHIPS 341-1317 and 341-1382, Main propulsion turbines
   - NAVSHIPS 353-0170, 353-0175, and 353-0187, Carrier forced draft blowers
   - NAVSHIPS 353-0163, Hardie-Tynes forced draft blowers
   - NAVSHIPS 347-2693, Worthington main feed pumps
   - NAVSHIPS 347-4194, Byron-Jackson main feed pumps
   - NAVSHIPS 347-3684, Buffalo main feed booster pumps
   - NAVSEA 0947-002-0000 and 0947-145-3010, reserve feed transfer pumps
   - NAVSHIPS 347-3683, Buffalo main condensate pumps
   - NAVSHIPS 347-3606, 347-4279, 0947-102-5010, and 0947-126-7010, auxiliary condenser condensate pumps

AD-A080 806 ARINC RESEARCH CORP ANNAPOLIS MD F/G 13/10
DESTROYER ENGINEERED OPERATING CYCLE (DDEOC). SYSTEM MAINTENANC--ETC(U)
NOV 79 C P BEYERS, R B BROWN, R G SIEVERT N00024-80-C-4026
UNCLASSIFIED 1671-04-3-2119 NL

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- NAVSHIPS 347-3146, main circulating pumps
- NAVSHIPS 347-3716, main circulating pump turbines
- NAVSHIPS 347-3618, 347-4032, and 347-4199; and NAVSEA 0947-102-3010, auxiliary circulating pumps
- NAVSHIPS 347-4302, main fuel oil service pumps
- NAVSHIPS 347-3427, 347-3933, and 347-4186, port and cruising fuel oil service pumps
- NAVSHIPS 347-2336, main lube oil pumps
- NAVSHIPS 347-3108, main lube oil pump turbines
- NAVSHIPS 345-0413, lube oil purifier

4. Allowance parts lists (APLs) for selected components of the CG-16 and CG-26 Class 1200 psi propulsion plants

5. Maintenance index pages (MIPs) and maintenance requirement cards (MRCs) for selected components of the CG-16 and CG-26 Class 1200 psi propulsion plants

6. Trip reports, ARINC Research Corporation representative visits to USS LEAHY (CG-16) on 26 June 1978, USS ENGLAND (CG-22) on 6 July 1978, COMNAVSURFPAC staff on 7 July 1978, USS HALSEY (CG-23) on 3 and 4 January 1979, USS DALE (CG-19) on 9 March 1979, and USS WAINWRIGHT (CG-28) on 10 and 11 May 1979.

7. PERA(CRUDES) Ship alteration manuals for CG-16 and CG-26 Classes, September 1978.

8. TYCOM alteration matrix for CG-16 Class, 8 February 1978.

9. COMNAVSURFLANT Alteration management system, alteration status matrix for CG-16 Class, 22 February 1978.

10. COMNAVSURFLANT Alteration management systems, shipalt summary matrix for CG-16 Class, 15 March 1978.

11. Shipalt briefs and SAMIS shipalt information for 1200 psi propulsion plants.

12. System maintenance analyses (SMAs) for 1200 psi propulsion plant subsystems and components:

    - SMA 101-221, FF-1052 Class main propulsion boiler system
    - SMA 37-108-221, DDG-37 Class main propulsion boilers
    - SMA 101A-221, FF-1052 Class automatic combustion control and main feed pump control systems
    - SMA 37-109-2211, DDG-37 Class automatic boiler control system and high pressure steam reducers

- SMA 106-231, FF-1052 Class main propulsion steam turbine system
- SMA 37-105-231, DDG-37 Class propulsion turbine system
- SMA 103-251, FF-1052 Class combustion air system
- SMA 37-104-251, DDG-37 Class combustion air system
- SMA 102-255, FF-1052 Class feed and condensate system
- SMA 37-101-255, DDG-37 Class feed and condensate system
- SMA 110-256, FF-1052 Class saltwater circulating system
- SMA 37-106-256, DDG-37 Class saltwater circulating system
- SMA 112-260, FF-1052 Class fuel oil service and transfer system
- SMA 37-102-261, DDG-37 Class fuel oil service, filling, and transfer system
- SMA 109-240, FF-1052 Class main lube oil and propulsion transmission system
- SMA 37-107-240, DDG-37 Class main lube oil and propulsion transmission system

13. OPNAVINST 4790.4, Material maintenance management (3M) manual, volumes I, II, and III, June 1973.

14. CG-16 and CG-26 Class maintenance critical equipment lists, ARINC Research Corporation, 31 March 1977.

15. Selected Items for Analysis Lists for CG-16 and CG-26 Classes, ARINC Research Corporation report 1653-06-TR-1875, February 1979.

16. Ship alteration and repair packages (SARPs) for the following CG-16 and CG-26 Class ship regular overhauls:

    - USS LEAHY (CG-16), 1977
    - USS GRIDLEY (CG-21), 1973 and 1978
    - USS ENGLAND (CG-22), 1975
    - USS HALSEY (CG-23), 1977
    - USS REEVES (CG-24), 1977
    - USS WAINWRIGHT (CG-28), 1978
    - USS HORNE (CG-30), 1976

17. Departure report for USS LEAHY (CG-16) ROH, 1977.

18. DDEOC repair requirements for BOH for CG-16 and CG-26 Classes, July 1977 and August 1977, respectively.

19. NAVSECPHILADIV message 231713Z, June 1978; Subject: Asbestos-free boiler casing gasket, inspections

20. NAVSECPHILADIV letter serial 429 of 2 June 1978; Subject: VP atomizer modification for B&W type registers; shipboard evaluation of USS JOHN KING (DDG-3).

21. NAVSECPHILADIV letter serial 440 of 20 June 1978; Subject: 1200 psi steam propulsion plant improvement program; Yarway direct reading 2,500 psi boiler water level gauge, defective cap screw assemblies, replacement of.

22. NAVSEA Code 934E memo serial 6339 of 1 June 1978; Subject: Steam propulsion plant improvement shipalts.

23. PERA(CRUDES) technical repair standard (TRS) index, hull applicability, 27 March 1978.

24. 1200 psi steam propulsion plant shipboard test procedure number 221F1010130, Appendix C; test procedure number 261F5070030, indexes 30 (CG-16) and 39 (CG-26).

25. Steam propulsion plant improvement program (NAVSEA PMS-301) for 1200 psi ships shipalt program, advisories, and operational background, various dates.

26. Type commanders' coordinated shipboard allowance lists (COSALs), SURFPAC and SURFLANT, July 1978.

27. Dimmick, J.G., et al, "Acoustical Valve Leak Detector for Fluid System Maintenance," *Naval Engineers Journal* (April 1979).

28. Dickey, J.W., et al, "Acoustic Measurement of Valve Leakage Rates," *Research Supplement, Materials Evaluation* (January 1978).

29. Anderson, G. and Carpenter, F.T., Jr., "ASNE Day Comments [on] Technical Session Papers (comments on "Acoustical Valve Leak Detector for Fluid System Maintenance" by J. Dimmick, et al, presented at ASNE Day, April 1979)," *Naval Engineers Journal* (June 1979).